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ABSTRACT

The papers from a conference on computer communication networks are divided into five groups--trends, applications, problems and impairments, solutions and tools, impact on society and education. The impact of such developing technologies as cable television, the "wired nation," the telephone industry, and analog data storage is projected. Various applications of communications networks are described; among them are a national biomedical network, an air traffic control system, and a modernization of the U.S. Postal Service. Some of the problems caused by costs, time-sharing, voice grade communications and other technical considerations are examined. The solutions to some difficult technical problems are offered. The effect on society of increased communication between computers is discussed with particular emphasis on the rights of the individual to privacy and confidential information. (JY)

PROCEEDINGS OF THE

FIRST ANNUAL COMPUTER COMMUNICATIONS CONFERENCE AT SAN JOSE STATE COLLEGE

JANUARY 24 - 26, 1972

COMPUTER COMMUNICATIONS, COOPERATION OR CONFUSION

A COMPUTER COMMUNICATIONS CONFERENCE AT SAN JOSE STATE COLLEGE

1

In cooperation with:

San Francisco Peninsula Chapter ACM, San Francisco Communications Technology Group IEEE, NASA/Ames Research Center, Philco-Ford, Pacific Telephone and San Jose State College

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IMPACT OF INFORMATION TECHNOLOGY ON THE FUTURE DIRECTION OF U.S. SOCIETY

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Forecasts of future-shaping applications of information technology are by now commonplace--in banking and finance, industrial process control, engineering design, research and education, medicine, new types of communication services, individual home applications, and many other areas.

Negative impacts of information technology typically mentioned include invasions of privacy, Big Brother surveillance by governments, movement toward a centralist cybernated economy, political leadership problems brought about by the possibility of "instant plebiscite."

Advances in the storage, retrieval, processing and distribution of knowledge have become an indispensable part of the technostructure of modern society. The business life of the nation could not go on without them. The new ways of handling information have brought about fundamental changes in governmental and political processes. They have altered the psychological and cultural attitudes of hundreds of millions who have only the haziest notions of how the new technology works.

The cultural impact has already begun to show itself. There is a schism between those of the elite group who know how to exploit the systematized knowledge in which the new information technology traffics--and the majority who fear manipulation by that knowledge power which they only dimly understand. This split is manifested in a growing anti-expertise sentiment.

The fears have some foundation. It is easy to imagine ways in which these technologies might be used to facilitate the centralization of power; the cynical manipulation of political, economic and cultural publics; the regimentation of thought and work; the devaluation of every part of life that cannot readily be quantified or otherwise processed.

Information technology can be a potent tool applied to the governing of societal processes and the resolution of societal problems--possibly thereby contributing to an ever more powerful centralized government. It can also constitute a means by which decentralized democratic government can be facilitated. The balance between these two may be one of the most fateful choices the society will make in the last third of this century.

This issue is but one facet of a more fundamental problem the society faces--namely that the multitudinous individual microdecisions which comprise the everyday activity of the technostructure (e.g., to employ knowledge, to apply a new technology, to create and take jobs, to use scarce resources, to affect the environment) are currently adding up to largely unsatisfactory macrodecisions. There are a number of reasons this is true to an extent it was not true in the past. A tendency. for the past four decades at least, has been for increasing reliance on government to provide the regulation to keep the macrodecisions in a tolerable range. But this leads in the direction of bureaucratic giantism and centralized control. There is another way to go; however it requires a shift in the operative values of persons and institutions.

Impact of CATV on the Communications Industry and the Public, E. M. Allen, Western Communications, Inc.

As a representative of the CATV industry, it is indeed a pleasure for me, both as a Bay Area cable television operator and as a Director of the National Cable Television Association, to be offered this opportunity to address your Conference.

Frankly, as only about 8% of the people of the United States even know what the CATV industry is (and that CATV stands for "community antenna television"), our industry needs and welcomes the greatest possible public exposure we can get. In this regard, some people refer to us as Cat-V and, on occasion, Cat-Five. To clarify at the outset, our industry is not Cat-V or Cat-Five or, for that matter, Pay Television - it is CATV - it is "community antenna television" - it is "cable television". However, as I shall try to point out in my remarks, we now have the exciting opportunity and in the rather near term, to become something substantially more than just our present "good reception" service.

As the Bay Area has such a high degree of CATV subscribership, I am going to assume that all of you know what is meant by CATV. Therefore, I'll avoid the kindergarten definitions as to just what CATV is (or isn't) and go directly to my remarks.

I should like to address my remarks to the question "What will be the impact of cable television on the future of our present communications industry". It wasn't too many years after cable television came into being (about 20 years ago) - after broadcasters got over the shock of having someone expand their area of coverage for free - that Monday morning quarterbacks, prophets, and other assorted seers began making predictions about CATV's impact on radio, television, newspapers, magazines, the Telephone Company and just about every other form of communications that exists in this country. Some saw the early demise of television - just as earlier Cassandras saw the demise of radio as soon as those fuzzy, jerky images first appeared on that unwieldy box in our living rooms. In fact, as an owner of a radio station, I must admit to being one of those early Cassandras and even went so far as to send my business cards back to my local printer to have them over-printed in red with the message "Help stamp out TV". And, of course, it was predicted that newspapers, as we presently know them, would ultimately be doomed just as soon as cable got around to transmitting out daily news by facsimile.

Now, some ten years after this initial wailing began, the prophets of doom are still at it. Cable television has grown quite a bit - there are now over 2,700 systems serving some six million homes in about 4,500 small communities across the nation - and cable television's impact is now an even hotter topic. My reference to these early prognosticators may give you an idea of what we are up against in trying to predict the future impact of cable television. With just a few exceptions, we don't have much actual experience to go on. To steal a line Alvin Toffler used in his book, Future Shock, "To prophesy is extremely difficult, especially with respect to the future".

Keeping that in mind, let me offer this proposition: The impact of cable television on our existing communications system will be quite minimal. On the other hand, the impact of cable on the public at large will be nothing less than revolutionary. Can these two statements square? I hope to marshall the evidence to show that they can.

First, I would ask you to consider this rather mundane truth. Times change, and we are forced to change with them. When you consider cable television's impact on broadcasting, for example, you should remember that broadcasting, in five or ten years time, will not be what it is today. The same is true of newspapers and, probably, of radio. Look closely at each of these media and try to recall what they were like twenty years ago. I think you will find that there are substantial differences between what you saw and read and heard in 1950 (and how it was presented) as opposed to what you see and read and hear now (and how it is presented). Perhaps some will argue there is not enough difference. But differences there are - and there will be many more by 1980. The pace has quickened - the needs have changed.

Admittedly, cable communications will be one of the elements that stimulates change in these businesses, or at least I hope it will. But it is by no means the sole element. There are other potent forces at work - social, political, and governmental pressures, previously unarticulated public needs, new technologies and techniques. Business has adapted in the past, and it will continue to adapt. Competition is still a good idea and still the best way I know of to get a better product. In short, there should be little question that the media of the future will be quite different from what they are now.

Parenthetically, I sometimes think this is one of the great problems that exists between broadcasters and cablemen. A television broadcaster looks at his business now and, for the life of him, can't imagine how he can continue that business with competition from Nicholas Johnson of the FCC, the D.C. Court of Appeals, irate mothers, minority groups on both the left and right, newspapers, radio and cable television to boot. The catch is, even if cable didn't exist, he would probably be doing something quite different in the future anyway because of these and other pressures.

In considering cable's impact on existing media, let's first look at the TV networks, independent UHF and VHF television stations and newspapers.

In seems clear that there will be minimal, if any, adverse economic impact on the networks or their affiliates. Their general share of the audience in America seems impervious to assaults of diversity. It will be a good long time before any cable outfit, network or otherwise, is in a position to compete with the networks for programming.

Perhaps the best indication of cable's competitive threat to the networks comes from network executives themselves. In the past year I have seen statements (in Business Week and U.S. News & World Report) from NBC's Julian Goodman, ABC's Jim Duffy, and CBS' David Blank all dismissing the threat of cable. In fact, Mr. Blank says, somewhat deprecatingly, "In the decade of the 70's, I'm doubtful that more than 25 percent of the country will be hooked up to cable". Well, right now less than ten percent of the country is hooked up. That extra 15 percent doesn't seem to bother him in the least. At least publicly, the networks don't seem to fear cable's impact.

What about independent stations, both UHF and VHF? Here is where the so-called "controversy" lies. We've seen detailed economic studies and statistical compilations attempting to gauge the impact of cable on these TV stations. Frankly, the issue has just about been beaten to death. What can we glean from all the debate? First, there is no documentation of any TV station going under, or even suffering substantially, because of competition from a cable system. That is based upon empirical evidence. In fact, a few years ago a friend of mine in the cable television industry offered a reward of $10,000 to any television station which could demonstrate that it had been substantially adversely affected by cable television competition and, to date, that reward is still uncollected.

But from there we slop into the realm of prophesy. The hard-line adamant broadcaster expresses concern about what happens when distant television signals are brought into "his" market. He claims those distant signals will destroy him.

Yet, every major independent and impartial study in recent years (and I emphasize "independent" and "impartial") has recommended fewer restrictions on cable. The Rand Corporation reports, the new Sloan report, the report of President Johnson's Task Force on Communications Policy, the Office of Telecommunications Policy, the Justice Department's memoranda on cable policy, even the Federal Communications Commission's own detailed and exhaustive staff studies argue against the demise of so-called "free TV" if the present restrictions on cable are loosened.

In fact, many of these studies claim that independent stations in both large and small markets, especially UHF stations, may well be helped by the advent of extensive cable penetration. That is certainly the case here in the Bay Area - just ask Channel 44 in San Francisco, or Channel 40 in Sacramento, or 36 in San Jose. In the case of UHF stations, the extended coverage provided by cable, equalized (and better) signal quality, and the ease of tuning which CATV gives would seem to more than offset any audience diminution caused by multiple signal availability. And, in yet another way, predicted audience fragmentation will also be lessened by the fact that these same studies show that CATV subscribers tend to watch more television, rather than viewing the local signals less.

Even if at some point in the future, it could be adequately demonstrated that cable competition is significantly harming a television station to the detriment of the public interest, steps could be taken to meet that problem on an ad hoc basis, through what is called a "failing station doctrine". What should not happen, however, is that public policy be predicated on questionable and undemonstrated presumptions of some imagined threat. In such a case, only the public is the loser.

What of newspapers? Again I would turn to a spokesman for that industry. Stanford Smith, President of the American Newspaper Publishers Association, in comments recently submitted to President Nixon's Cabinet Committee on Cable Television said, "We view the cable medium as a positive adjunct or complementary avenue for the dissemination of information - specifically news". Interestingly enough, ANPA also attached to its comments an article titled "Local Programs on CATV - No Major Menace to Newspapers".

I think it is safe to say that the newspaper industry sees no tremendous threat from expanded cable television service. Certainly, for the near term, printed media have a time advantage over all audio/visual media in that people can and will read a newspaper or magazine when they want to. Additionally, cable's competition for the local advertising dollar with the newspapers has been likened to the competition that exists today between a newspaper and an independent UHF station -- certainly not an unhealthy situation.

Perhaps, many more years down the pike, cable may represent more of a threat to newspapers, but I would suspect the threat will come not from cable per se, but from such problems as newsprint and production costs, and union troubles.

In the meantime, I, as does Mr. Smith, see cable as a positive adjunct to newspapers. Already we are seeing many situations where local small town newspapers are developing cooperative arrangements with CATV systems.

Finally, a word about the telephone company. As you may know, telephone companies have been barred from providing CATV service in the same area where they provide the telephone service. This and other FCC rulings have made telephone company involvement in the cable industry difficult. However, that is a matter of Federal regulatory policy, not cable competition per se.

On the other hand, as cable grows and begins to acquire the means for providing extra services - such as utility meter reading - an interesting competitive situation could begin to develop between cable and the utilities. It's difficult to say much about what will develop here in terms of Federal policy - but it's hardly thinkable that cable will put the telephone company out of business. They've already wired up the nation; we're just getting started.

The second half of my proposition is that CATV's impact on the public at large will be nothing less than revolutionary (and this will involve you). You may fairly ask that if cable's impact on everything else will be minimal, how can it have a revolutionary impact on the public? Several things explain this. First, and most obviously, all of cable's benefits are not going to come showering down on the public in the next two years. In particular, some of the more esoteric services - facsimile reproduction, information retrieval through computers, home shopping, burglar and fire alarm service - although technologically possible now (to some degree), are some years away on any large scale. However, you should know that in many of these areas pilot programs are already in the works or operating.

Secondly, and most important, don't presume that cable will be doing only those things that other media are now doing. If that were true, then cable wuuld have to supplant other media in order to be viable.

If you look closely, you find that cable will be supplementing not supplanting existing media services, offering new services, meeting needs that are not now being met due to economic and technical limitations. This is why cable's impact on the public will be revolutionary.

These services touch upon almost every aspect of modern man's existence. In addition to their intrinsic value, they hold the promise of spreading the benefits of technology to low-income and disadvantaged groups by making education and information more readily available. In fact, it is the less-favored groups of society who can be the real beneficiaries of the development of CATV, both absolutely and relatively.

Let me be specific about some of the possibilities that seem most immediately realizable. Can open circuit (or over-the-air) television serve as a means for almost unlimited local expression, for community or even neighborhood expression? I submit it cannot. It tries to, and in some cases it does a good job, but it is limited by its single channel and, because its financial base is commercial advertising, the need to reach a mass audience. I don't think you will find too many broadcasters who can or would argue that point. Cable can, through leased and public access channels, and truly local origination facilities, offer this unique opportunity because its financial base is its subscribers.

What about the educational possibilities? Again broadcast television is limited. In addition to the obvious single channel limitation, educationally speaking it is inflexible, passive, and certainly too expensive. It is not insignificant that what was once called "educational television" is now generally called "public television". Despite years of involvement, untold experiments, many false starts, and millions of dollars, television and education have not had the happiest of marriages in this country.

Several weeks ago, a Rand Corporation study concluded that cable television can serve instructional needs in education in a far more flexible and expanded manner than can over-the-air broadcasting.

There are very real opportunities for capitalizing on the educational potential of the audio/visual medium through cable television, provided educators and cable people can get together in a realistic, cooperative manner (and that hasn't always been the case). This will be especially true when two-way interactive cable becomes a reality.

So far, I have touched only on the new cable services which seem to be most immediately possible. I have deliberately avoided a discussion of the "blue sky" aspects of our future. In fact, I have been critical of our industry for the emphasis some members of the industry seem to put on these exotic "blue sky" services. Frankly, in the heat of competitive franchise battles, some members of our industry have promised the local governments services that, at the moment, we just can't deliver. Some of the publically-held CATV companies seem to have a penchant for extolling the "blue sky" in our future - perhpas as a way of supporting the price of their stock. I think, for the moment, we should soft-peddle this "blue sky" talk - we are only doing our industry a disservice.

However, at a Conference like this, we must admit that the "blue sky" does exist and in the foreseeable future the computer industry and the CATV industry are going to be working partners in turning the "blue sky" into reality.

I mentioned the fact that there are some 2,700 cable systems presently operating in this country. Our industry has a present image of itself as a one-way distribution system and these 2,700 systems, while capable of delivering information into the home, do not have the ability to extract information from the home. Thus, our future depends totally on the two-way capability of systems yet to be built. The consumer has a present desire (and it has been building for years) to end his passive viewing role and actually communicate his wishes for goods and services without leaving the comfort of his home. As the Chairman of the Federal Communications Commission, Dean Burch, told our National Convention in Washington last July, "What ultimately tips the scale in favor of cable's orderly growth are the benefits cable can bring over and beyond the mere distribution of commercial broadcast signals. These supplemental benefits are...the key to cable's future. Not sometime in the next century, or the next decade, but starting now". Among the services cited for this "remote control living" are:

- Doctors making electronic house calls via cable.
- Businesses providing employees at-the-desk training.
- Improved police and fire department contact with the public.
- Instant polling of the populace on vital issues.
- Consumer retrieval of facts from computerized libraries.
- Shopping from the home.
- Transmission of business information from office to office by special circuits hooked up to television sets.

Yes, the true future of our industry lies in the two-way systems yet to be built. These systems will be built - the Government will insist they be built - the consumer will insist they be built. In fact, prognasticators in our industry envision that ten years from now only one-fourth of our income will come from the service we are presently providing (the distribution of more and better television pictures) and three-fourths of our income ten years from now will be from services we are not now providing (or, in some cases, not even dreaming of).

A certain limited number of two-way experiments are presently under way. One of my own systems (in South San Francisco) has an operating two-way line from its studio to the headend. Experiments are under way in Los Gatos and El Segundo, California, in Reston, Virginia, in New York City, in Orlando, Florida, and in Overland Park, Kansas.

Just how fast this two-way concept will develop is, realistically, a matter of economics. While we have a limited capability now, much more R&D must be done on some of the necessary hardware to fight the costs down to where they are realistic. For example, it is estimated that, at the present, the simplest two-way terminal would presently cost between $200 and $400. If you add a feature which would permit the customer to insert his credit card into the terminal, the cost could go to $500. A feature which would enable the gas or water company to read the meter without sending a man into the house, could increase the costs of the terminal device to as much as $600. If you add a video taperecorder-player (which could enable the customer to automatically record a TV program, store it in his TV set, and play it back through the set at a later time), the cost could go to $800 and if we are talking about a complete two-way video communication system, the terminal costs could soar over $1,000.

Another part of the economics, in addition to the cost of the hardware, is the customer's willingness to pay for these extra services. Stanford Research Institute, in their studies, feel that people will pay about $5 a month above their basic cable charge for each additional service that interests them - to a limit of about $20 per month for the entire package. Unfortunately, SRI also estimates that the present costs for such a package would be about $40 per month - or substantially out of the financial reach of our subscribers.

How far away, realistically, are these new services? The Rand Corporation feels that some of the simplest services are still at least five years away and that it may be a decade or more before many home subscribers can make requests over their cable for specialized information or services from many different sources. So, at best, we're not talking about the "near" near term. The new systems have to be built, the R&D has to be done, and the demand has to be generated.

So, in summary, my point is just this. Cable television will not destroy or supplant existing media. Those media will continue to exist; changing, adapting, doing what they best can do. Some of that change may be due to cable, but much of it will come from other pressure - pressures which business has always faced and will continue to face.

Conversely, cable will do that which it best can do - essentially what no one else has been able to do or has wanted to do.

I have said a good deal about impact today. In closing, let me plug in one more type of impact. That is the impact of government regulation on cable (at the local, State and Federal level) and of the continuing attemps to have cable's growth thwarted. For the past three years the CATV industry has been laboring under what amounts to an absolute freeze on its growth in the top 100 markets of this country - the markets which contain about 85% of our population. Last summer, the Federal Communications Commission, after years of deliberation and study, arrived at a compromise plan for cable's controlled and orderly growth which was presented to the Congress in a Letter of Intent on August 5th. Unfortunately, hard-line opponents of cable's growth were not disposed to accept that compromise. Through heavy pressure at the very highest levels of government, they have now succeeded in ramming through still another and still more compromising position. It was with substantial reluctance that I participated in our industry's national deliberations in which we ultimately (and most reluctantly) accepted this additional compromised position.

Now the new law has been written. Whether, or if, our industry is to be permitted to move ahead and serve the remaining 90-plus percent of the population of this country, will depend on how the language of this new Report and Order is translated into actual FCC regulation. The same forces who are motivated by political expediency and narrow self-interest are still working hard to dilute the ultimate capability of cable television. If they succeed, many of the services I have outlined to you today will be delayed, opportunities for important services needed now will be lost, and the public will be the big loser. That would be the very worst type of impact associated with cable television.

However, if I may shift from my former position as a Cassandra to that of a Pollyanna, I sincerely feel that, with this newest compromise position now a matter of public record and concurred in (albeit reluctantly) by the broadcast industry and the cable television industry, "reasonable men reasoning together can arrive at reasonable solutions". It is said that the hallmark of a true compromise is that nobody is fully satisfied with the result. I can assure you that neither the broadcast industry nor the cable television industry is fully satisfied with these newest regulations. And so, while the near term for cable television is not as near as I should like to see it, I think we are now ready to take that first step down the long road which will lead us, ultimately, to a communications revolution of unparalleled benefit to the American people and in a manner that some of our "blue sky projectionists" have not yet even dreamed.

Cable television, as I see it, will be the most exciting and potentially explosive industry on the horizon in the next decade. It will be absolutely on a par with our space efforts of the last decade but will truly reach and touch the lives of so many more average American citizens. It goes without saying, that I am both proud and privileged to consider myself a part of this revolutionary new concept of service to all mankind.

Computer Communications in the Wired Nation of the Future

by

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Broadcast television is like the passenger railroad, taking people to scheduled places at scheduled times. Cable television has the potential to be like a highway network permitting people to use their television sets like personal automobiles, selecting information, education and entertainment at times and places of their own choosing. The technology of cable television (especially two-way cable television), video cassettes, computer information systems and communications satellite can permit the creation of an 'information utility' which could be used to foster equal social opportunity for every resident of the United States.

Present cable television systems. At present there are 57 million television households, of which 4.5 million are served by cable (1). The typical cable television system now has 12 or fewer channels of television capacity, primarily used for retransmission of broadcast television. Revenue is obtained by selling (at rates of about $5 per month) better quality television signals than those available over the air, or by selling reception of distant signals not locally available.

A single television cable has the capacity for many more than 12 television signals, since present day cable amplifiers can amplify frequencies from zero to about 300 Megahertz (MHz) and a bandwidth of 6 MHz is required for each color television signal.

In order to estimate the cost of the hardware for a 24-channel system (and more complex systems discussed below) the capital cost of a complete cable system is first calculated. The capital cost is then converted to a monthly cost and then to a cost per terminal hour that a user would expect to pay and a cost per channel hour that would have to be paid by any group or individual making exclusive use of a channel.

The capital cost of a cable system per user depends strongly on the density of homes. For a density typical of urban locations with medium density, 50,000 homes or apartments can be served by 100 miles of distribution plant. Taking $15,000 per mile as the cost of the underground trunk line cables, allowing $45 per subscriber for house drops, and $50,000 for head-end buildings, antennas and related costs, a 10,000 subscriber system with 50% market penetration would cost $110 per subscriber. These cost estimates are for typical underground systems and are based on information provided by the National Cable Television Association as reported by Comanor and Mitchell (2). To convert capital cost to monthly cost, we can assume a system life of 10 years, an interest rate of 8% per year and maintenance cost of 10% per year, obtaining a monthly cost of 1/48 of capital cost. The monthly cost that goes with the capital cost figure of $110 is then $2.29 per month per subscriber. If we assume 80 hours per month of usage by each terminal, the average cost per terminal hour is $0.03. If we assume 400 hours per month of transmission on each channel and 24 channels, the average cost per channel hour is $2.38.

Two-way communication. New cable television systems are now being installed with channel capacity for communication of data from subscribers back to a computer at the head-end of the cable system (3). Present system designs permit a single computer to collect information from as many as 10,000 users in less than two seconds (4). These same systems can automatically record whether the television set is on and what channel it is tuned to. Figure 1 shows the network configuration for this type of system.

The terminal configuration at the subscriber's end of such a system is likely to take the form shown in Fig. 2. In this configuration the house drop cable or cables are connected to a unit containing a modulator-demodulator (modem) and a digital memory. When a signal is received from the computer in the data channel it is demodulated and, if the address is that of this terminal, the data signal stored in the memory is read out, modulated, and transmitted upstream to the computer. Subscriber data messages are written into the memory through a 12-button pad. A paper tape recorder may be used to record the subscriber's message as he types them or to record acknowledging signals from the computer.

The cost of a terminal configuration of this type, apart from the television set, is in the range of $100 to $300 depending on the detailed design requirements and the quantity produced. We have estimated $200 for all items in Fig. 2 except the television set. Quantity production, on the order of tens of thousands of terminals per year, is assumed. Additional costs for a two-way system of this type include the cost of a return cable or upstream lowband amplifiers in the existing cable plus the cost of a computer at the head-end for polling, data storage and processing printout.

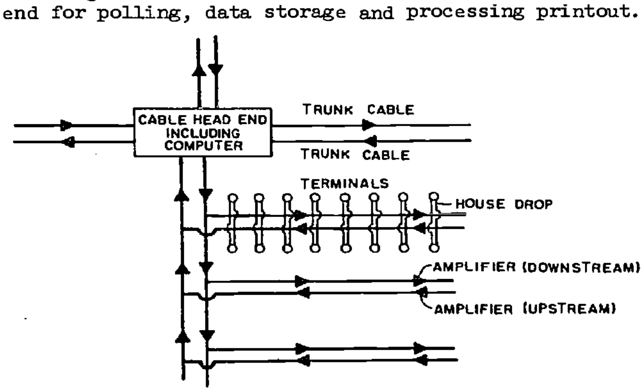

Fig. 1. A two-way cable TV network.

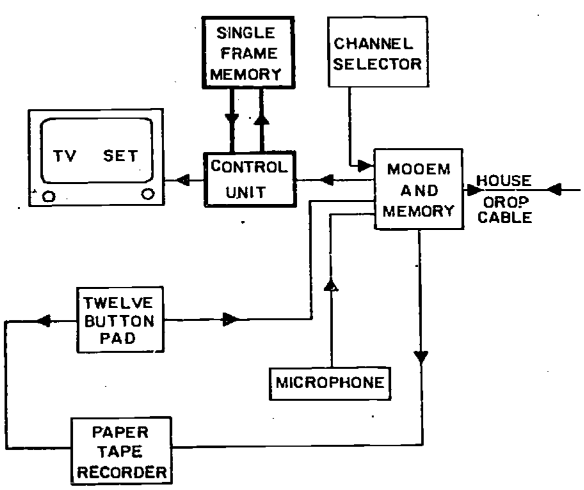

Fig. 2. Terminal configuration of a two-way cable TV system.

Table 1. Typical Hardware Costs in Dollars for Three types of Cable TV Systems (not including TV set costs).

Type of System \ Cost Category	Capital Cost per Subscriber	Monthly Cost per Subscriber	Cost per Terminal Hour	Cost per Channel Hour	Maximum Number of Simultaneous Users	Maximum Number of User Terminals per Channel	Maximum Number of Pictures Simultaneously Displayed
Conventional 24 Channel One-Way TV (National Average Underground Trunk Costs)	110	2.29	0.03	2.38	10,000	10,000	24
Interactive TV with SRS	320	6.67	0.07	6.95	10,000	10,000	24
Interactive TV with SRS and Single Frame Local Storage	520	10.82	0.14	11.26 0.04 to 0.37	720 to 7,200	30 to 300	720 to 7,200

We estimate $10 per subscriber for these items in a 10,000 subscriber system of the type and density considered above. When these costs are added to the one-way system costs, the total capital cost per subscriber becomes $320.

Techniques such as those recently demonstrated in the Reston, Virginia cable system also permit 'time-sharing' the cable communication capacity for analog data (still pictures), with the television set becoming a computer display terminal (5). Completely individualized computer-aided instruction, information retrieval and other computer services can thus be brought to every home. This technique, using a local video storage device, permits on-demand display of digital or still video messages transmitted from a central location at reasonable cost. The technology required for this service is usually referred to as a 'frame-grabber' because it takes a single television picture (or 'frame') lasting 1/30 of a second, grabs it out of all the other frames being transmitted on the cable, and then repeatedly supplies it to the set so that the viewer sees this frame as a still picture on his set. The key component of such a system is the unit that stores the frame locally. The system demonstrated in Reston utilized a commercially available videotape recorder for this purpose. Other approaches are possible, including storage tubes such as the plasma display tube (6) and recirculating delay line systems using delay lines with delays of 1/30 second or more.

A critical cost parameter in such a system is the number of users that can share a channel. If the average time between frames for each user is one second, then the maximum number of users per channel is 30. If the average time is 10 seconds, 300 users can share the channel. We have estimated $200 per terminal for a 'frame-grabber' that could be integrated with the digital audience response capability discussed above. The cost estimate for this type of system is less certain than the other cost estimates given here, because frame-grabber technology is still in a state of rapid change. The cost per channel hour given in Table 1 is given first for this system as a cost for the channel as a whole and then as a cost for an individual using the channel either 1/300 or 1/30 of the time, corresponding to an average time between frames of 10 seconds or 1 second.

<u>An information utility</u>. The technical potential described above can make possible an information utility providing an individualized communication system with on-demand information storage, processing and transmission capability (excluding motion video, which would have to be shared with others at scheduled times). It may be visualized as a communication network providing access to a large number of retrieval systems in which nearly all information, entertainment, news, library archives and educational programs are available at any time to any person wanting them (7).

The information utility is likely to be a series of different overlaid computer-communication networks, some competing with one another to provide similar functions, others providing different functions. These separate networks will share many of the same physical facilities, such as user terminals, communication lines and a switching computer. It is likely that each different network or service will have its own separate computer, central data file, and computer software.

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THE FUTURE OF THE TELEPHONE INDUSTRY, 1972-1985

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Abstract

The paper summarizes the results of a study conducted in 1970-1971 by Paul Baran and the author, sponsored by the American Telephone and Telegraph Company, to examine the future of the telephone industry. Virtually all of the necessary information, largely judgmental, was obtained from panels of experts, who interacted anonymously through a series of questionnaires circulated through the mails. Two hundred ten expert "respondents" were selected individually for their personal technical knowledge and not as representatives of any organization. They came from a large number of organizations, including the Bell System. The conclusions of the experts deal only with probability of developments, rather than with their desirability or lack of desirability. In very general terms, the findings suggest that the future of the telephone industry appears secure. Major growth is anticipated in many sectors of the business, and the services provided by this industry are not at variance with the long-term goals and needs of any major sector of our society.

There are, however, some changes on the horizon, almost all originating outside the telephone industry. These are (1) a movement to a form of competition in some sectors of the business, (2) shifts in the nation's value system, (3) an under-current of public dissatisfaction with all industries, especially the more regulated ones, and (4) increasing adversary encounters with some previous supporters of the telephone business. The fundamental changes seem to hinge on the redivision of power among various sectors of society. It seems likely that the telephone industry will be able to live with the changes which appear to be coming down the road--but with varying degrees of comfort.

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A REQUIEM FOR ANALOG DATA STORAGE

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The supreme success of digital techniques comes from the speed and accuracy with which they can process data. Why then are the users of business EDP systems so often frustrated by the mountains of output that seem necessary to obtain a few key facts?

One reason is that the digital strengths in processing have hidden the two weaknesses of digital storage. First of all, digital storage is expensive. It is true a bit may be stored on tape for 10^{-6} cents but a bit is a very small amount of information. A single 8-1/2 x 11 inch page can hold several million bits, and so cost several cents to store. Since business files often contain 10^7 to 10^8 pages, these costs become major.

Therefore, usually without realizing it, the assumption has spread that all information may be abstracted and that only this small part of the original need be stored. Now, with 4,000 characters to a page, the number of bits has been cut 100:1 and digital storage becomes economical. But it is this abstracting process that is the Achilles' heel of EPD systems, for all too often it is the rejected piece of information that contains the odd fact that later is the key to why the process failed. In trying to prevent this, more and more information is abstracted and, worse still, more and more must be presented to the eventual user.

Analog storage attacks the problem from the other end. All is stored, at very low cost, and with tremendous (visual) redundancy. Error rates, by digital standards, may be absurdly high. One error in 10^6 is perfection and one in 10^3 is quite usable. Storage costs of 0.2 cents per 8-1/2 x 11 inch sheet are history (either on magnetic tape or film), and further reductions are already possible in the laboratory.

One may object that the output of such a system is cluttered with even more redundant information than the digital; however, the form this redundancy takes is often very different. The brain's ability to detect patterns, or to pick out the odd element, whether it be one number or one fingerprint out of thousands of similar ones, has yet to be equalled by a machine.

Thus, both analog and digital storage systems have their places: the analog where the emphasis is on storage, and where the risk of abstraction is high; the digital where data processing is the key. Business files, fingerprints, photographs, and medical records are good examples of where the loss by digital abstraction or conversion generally far outweighs any gain from the ability to process the information.

PATHS TO AN INFORMATION UTILITY:
An Introduction to a Seminar on
Applications of Computer Communications

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What is happening in computers and communications has been called an "explosion," a "revolution," and a "discontinuity." Where this joint revolution is heading has been called "instant world," "electric supermarket," "wired nation," "information utility," and "global village." Even these broad terms may be too definite since, as Gordon Thompson points out, "the assumption . . . that we really know what we are building is essentially groundless."

It is quite clear, however, that wherever things are headed, the progression will be through specific, discrete applications involving the major "revolutionary" elements, of which four immediately stand out. There is a revolution in the complexity of socio-technical problems and probably the beginnings of a user revolution: Confronted with proliferating new "post industrial" problems, users are beginning to search actively for suitable new information tools. The well known "computer revolution" and the "communications revolution" are perhaps finally ready to be forged into just the kind of powerful information tools needed by users to cope with the "problem revolution."

This conference occurs at a good time to examine the confluence of these four revolutionary streams, and to examine: the general trends and specific applications driving computer communications forward; the hurdles to be encountered and the means of surmounting them; and the social problems of "wiring a nation for computers."

The papers in this Applications Session typify interactions between system elements likely to be involved whatever exact form information utilities might eventually take. Hopefully a mere handful of selected papers may nevertheless represent a broad range of specific problems, user communities, communications media, and computer applications. The topics include: medical databanking over a terrestrial/space satellite communications network; wideband satellite interconnection of widely separated computers; digital interconnection of inflight aircraft with an air traffic control computer system; satellite linking of pupils in remote Indian villages to the computing power of a large university computer center for computer assisted learning; the merger of video and computer technology in Instant Retrieval Television; and computer communications projects of one of the Nation's largest information handling organizations--the Post Office Department. A further paper surveys several important applications not separately included in the selected sample.

The broader questions such as ultimate forms of the information utility, and its evolutionary adaptations to social resistance must be left to other sessions. This session concentrates on specific cases that indicate the rich variety of ways that the four "revolutionary" themes may be orchestrated.

The abstract debates and studies of ideal future systems will continue, but meanwhile the systems of the future are being incrementally built through specific applications such as these.

The likelihood that an ideal computer communications system will merely evolve without conscious external direction appears slight, and there is as yet little evidence either of a social agency capable of providing such direction or the national will to exercise such control.

The future computer communications network will not be "Systems Engineered" as the telephone network has been, for example. Therefore, we must hope that numerous applications such as in this session will provide a broad spectrum of technological capability and experience so that unpredictable social resistance can at least be approached with a degree of technological flexibility. In this way, in the absence of other clear goals, future national information systems may be realized that are "transparent," in the sense that they are at least not extremely socially-distorting.

A NATIONAL BIOMEDICAL NETWORK

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Presently there is not a formal plan by responsible government agencies and medical centers for a national health care or biomedical communications network for exchanging television and computer data between medical centers.

The requirements and costs of a communications satellite to provide a national health network for both metropolitan and isolated users is being study by Lockheed Missiles & Space Company under a contract to NASA's Manned Spacecraft Center at Houston, Texas. The growth of local and regional data communications networks throughout the nation (16 systems are in existence) and the growing use of automated data systems at medical centers are providing the elements which could be interconnected to form a national biomedical network. Such a network would benefit the general population and the medical community. The benefits of such a network increase tremendously with the growing use and sophistication of biomedical computer systems and automated equipment.

A brief review of the present status and benefits provided by the key elements available for such a network provides insight into the future uses and expected benefits and problem areas.

Special Purpose Computers

Special purpose biomedical computer systems such as the AML facility at the Palo Alto Medical Clinic can provide biomedical data in a form fully compatible with a data network. The AML system collects and formulates the patient's medical history and problems by asking questions through a visual display terminal. Patient response is by push button selection. Semi-automated sensors provide data inputs to the computer and special data can be entered by the medical technician. The completed, typed medical history and report of the medical examination is available upon completion of examination, which takes approximately 45 minutes per examination. Presently the typed medical record is sent to the requesting doctor by courier or mail. The record could be stored and transmitted by network to the doctor within seconds when requested for reference or update.

Extensive use of such equipment and a national network could eliminate the repetitious, costly collection and manual updating of medical histories. Most medical histories formulated today are based upon the patient's memory and understanding (or misunderstanding) of his past medical history. Personal medical histories could be formulated from successive inputs to medical terminals and would provide an accurate professionally prepared and documented history. Data banks of personal health records presently provide a research tool for studying national and regional health problems such as effects of pollutants. Available telecommunications and automated data systems can provide better health records for a fast paced mobile society.

General Purpose Computers and Teleprocessing

Present hospital information systems using general purpose computer and software systems provide improved financial and biomedical record keeping and monitoring of patient treatment. Teleprocessing is providing quick response analysis of biomedical data such as electrocardiograms.

Television

Television is being used to provide improved medical education, consultation, and aid to patients remotely located from a medical center. The use of television also provides quick access to the doctor in emergencies and a saving of travel time.

Display Terminals

The Lockheed Missiles & Space Company has assembled a medical data display console for demonstrating the means and effectiveness of selecting and examining data from remote sensors and data banks. The doctor can communicate with patients at remote locations on television, obtain and analyze biomedical data obtained from remote sensors, and order and examine selected historic biomedical data from microfilm or computer data banks. Real-time and historic data can be displayed in formats which are convenient for analysis. The console represents the next step in the use of communications and computer systems for improving health care of isolated patients or consultation with a remote medical specialist.

Communications Satellites

NASA's ATS-1 satellite is being used by the University of Alaska and Stanford University to provide improved medical aid to 24 remote villages in Alaska. Each of the remote villages utilizes the satellite for scheduled or emergency verbal communication with doctors at the University of Alaska. The doctor gives direction and instruction to a medical aid who treats the patient and observes the patient's condition. The system is credited with preventing deaths in emergency situations at isolated villages.

The next generation of communications satellites such as the proposed MCI Lockheed domestic communications satellite will be nonspinning, three axis stabilized and capable of providing over four times the communications capacity of present operational satellites. As the capacity, reliability, and expected operating life are increased, the cost of long distance television and communication links to remote areas will be reduced.

Problem Areas

One of the major problems in using the available elements to form a network may be the growing use of computers without a formal plan for a national network. The lack of computer interface and data format standards severely limits the machine to machine exchange of data between medical centers and hospitals. As each of seventy-five major medical centers in the nation utilizes one or a combination of several available computer systems and makes in-house modifications of system programs to suit local preferences for format and nomenclature, it will become difficult for a center to exchange machine data with each of the other 74 individualized medical centers. Approximately 7,000 hospitals and clinics in the nation could benefit from remote terminals providing access to the regional medical libraries, laboratories, medical schools and data banks of a national network. Without plans or incentives for regional or national networks, hospitals may obtain equipment which best meets the most pressing in-house needs at a minimum cost without regard to the future benefits or costs of converting equipment and modifying software for operation on a national network.

If firm plans for the development of a national health network are delayed for several years, options for satellite orbit stations and operating frequencies will become progressively limited due to the progressive establishment of other networks using the communications nets provided by satellites. Only a limited number of synchronous satellite operating stations are available along the sector of the equator which allows coverage of the United States, Canada, South and Central America. The available satellite stations must be shared with other nations. International communications satellite traffic has been doubling every three years. Such a growth rate for satellites providing communications over the Western Hemisphere will create an eventual shortage of satellite communications. How and when the shortage will occur depends upon future frequency allocations and technical progress in the reuse and conservation of radio frequency bandwidth.

FAA's "IDIIOM" AIR TRAFFIC CONTROL SYSTEM.

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The name IDIIOM, acronym for Information Displays, Incorporated (of Mt. Kisco, New York) Input Output Machine, has become associated with a project of the Systems Research and Development Service of the FAA to evaluate a computer generated visual display of long-range over water flight movements. Tests are being conducted at the Oakland Air Route Traffic Control Center, controlling facility for airspace overlying approximately 3½ million square miles of the eastern Pacific. Flight operations within that oceanic area totaled 95,366 during calendar year 1971.

Flight plans and movement reports are processed through a Varian mini-computer which generates both a graphic picture of aircraft position, identity and movement, and a tabular display of information quite similar to that used in conventional non-radar air traffic control.

Displays consist of two 21 inch cathode ray tubes mounted in consoles adjacent to the facility's oceanic control sectors. A function keyboard and a light pen give the operator a wide range of display selectivity. An ASR-35 teletypewriter provides means for input into the computer of movement messages received at the operating position.

On the graphic display, background mapping similar to radar video mapping is portrayed. The area displayed is merely a function of computer programming and is easily changeable. A normal setting to show the most heavily traveled routes between the West Coast and the Hawaiian Islands covers that portion of the Oakland Center's oceanic control area between the 24th and 48th parallels and from the West Coast to the 145th meridian. However, through a zooming technique, one degree of latitude and longitude can be expanded to cover the entire screen. Such a technique might be used to focus on an area of immediate interest or aircraft emergency.

Two methods for displaying aircraft movement are being evaluted. The first applies to a limited number of Boeing 747's equipped with data link which relay aircraft identification, positions as determined by inertial navigation and actual altitudes reported in 100 foot increments. The link between aircraft and the controlling facility is provided by Aeronautical Radio, Inc. (ARINC) using a high gain troposcat antenna. Aircraft involved in the test respond in sequence to the VHF pulse with the individual question and answer cycle being completed in 55 microseconds and repeated each 32 seconds. Data received through the relay is analyzed and aircraft positions are displayed in their proper relationship to the background mapping. Associated with each target symbol is a small sign identifying in alpha numerics the aircraft and its altitude.

The second method called correlation is used to display position and movement of aircraft not equipped for data link relay. Flight plan information including aircraft identity, type, speed, route, and altitude are first fed into the computer then activated by a position report at a fix within the oceanic sector. From that data and applying environmental information such as predicted winds aloft, the computer determines aircraft position in a manner comparable to pilotage by "dead reckoning". Aircraft identities and altitudes are displayed as alpha numerics in a manner identical to that used for aircraft reporting through data link while the use of different target symbology provides a visual differentiation between the two methods of reporting. Target positions are updated at 2-minute intervals, and when routine position reports received through normal radio channels are fed into the computer, the target position and track is updated to reflect the reported location and recomputed ground speed.

Additional features include:

1. Velocity vectors associated with each target symbol indicating the direction of flight of the aircraft and its estimated progress within the succeeding 5 minute, 10 minute, 20 minute or 40 minute interval as called for by the controller.
2. Notification by a printout of the word LATE that a required position report is overdue.
3. A reminder by printout of the word HAND that an aircraft is approaching a jurisdiction boundary and that control responsibility should be released to a neighboring facility or sector.
4. A warning of possible loss of standard lateral or longitudinal separation between aircraft at the same altitude. This warning is indicated by a printout of the word CONFLICT in the lower lefthand corner of the graphic display and associated with the warning is the identity of all aircraft involved. In responding to that warning, the operator can call for route projection to show the point and time of conflict. From that information, the operator can make his control decision and can test his decision for validity by querying the computer for any additional conflictions which might result from a change of altitude, route, or speed on any or all of the flights involved. In such tests, the computer will indicate CLEAR or will print out new conflictions which would result from the proposed control action.
5. Special activity airspace may be electronically traced on the face of the graphic display. Such area descriptions serve as a warning and simplify procedures for segregation of airspace reserved for special military activity, missile impact, etc.
6. Computer programming established acceptable parameters for position reports, pilot estimates, and reported altitude. When information exceeding those parameters is received by the computer, it suggests that the controller question the validity by printing the letter V adjacent to the aircraft identification.

The tabular display gives statistical information. It can be called upon for complete flight plan information. In addition, it displays for all aircraft within the selected environment columnar groupings of:

1. The identity of each aircraft.
2. The last reported position (fix) shown in latitude and longitude or by designated fix name.
3. The time the aircraft was over that fix.
4. The flight level - actual when reported through data link.
5. The identity of the next reporting point.
6. The computer estimate at the next fix.
7. The pilot estimate at the next fix.
8. Ground speed, continually updated as each position report is received.
9. The present position in latitude and longitude reported to the nearest minute.

Additionally on the tabular display, the alert features, including notification or warning of potential conflictions, overdue position reports, pending transfer of jurisdiction or need for verification, are highlighted. This is accomplished by removing from the total grouping the line/s of data related to the aircraft in question.

The oceanic displays are not commissioned for air traffic control use and priority must be given to the test and development project. However, in limited applications to "live" traffic this method of visual presentation has provided gratifying support to the ongoing operations.

Controllers at oceanic positions using standard non-radar technique have used the display to confirm their own judgment. When changes of route may be needed, course information and target tracking provided by this equipment is far superior to the grease pencil and piece of string which must often be used in outmoded control methods. The displays have proven a distinct adjunct to the facility's Air Movement Information Service (AMIS) giving a continually updated picture of aircraft approaching an Air Defense Identification Zone (ADIZ) or operating within the ADIZ.

The equipment has been used as a briefing device in preparing for large scale military exercises. Pending missions have been entered into the computer and the entire air movement previewed visually in fast time by the controllers who will be involved in the exercise. Aircraft in military missions proceeding well beyond the limit of coastal radar have been "tracked" through the use of computer generated targets using the correlation method. This technique has greatly simplified re-identification of aircraft approaching the coast line and can often lead to a more efficient use of airspace.

As a research and development project, the immediate goal is to evaluate the display system as a control device. Available equipment has also been used for limited tests in the use of data link for relay of air traffic clearances. There are plans for evaluating a wide-screen display of oceanic traffic. And there is hope that the Oakland Air Route Traffic Control Center may be involved in early tests of the use of satellites in the relay of air traffic communications and movement.

In pursuing the long-range goal of continually improving air safety and service, there is considerable optimism that the technique of receiving and displaying flight movement information without the limitations of land-based radar may prove the answer to the problems in handling the steadily increasing volume of oceanic traffic.

EXPERIMENTS WITH SATELLITE DISTRIBUTION OF COMPUTER ASSISTED INSTRUCTION

by

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The Institute for Mathematical Studies in the Social Sciences at Stanford University maintains a large interactive computing system. It is used primarily for research and application in the area of computer assisted instruction. This means that in the research area the Institute is trying to define algorithms for learning and in the applications area the Institute supports a large timesharing computing system on which many students receive a part of their instruction.

The IMSSS system at present supports 11 high speed graphic terminals, 6 medium speed CRT terminals, 225 teletype terminals and a variety of other equipment. The teletype terminals are located at over 20 locations throughout the United States. This large terminal network requires a correspondingly large effort in data communication by IMSSS in addition to supporting the time sharing system necessary for upwards of 125 on-line users.

The data communication system servicing these terminals is conceptually simple. As seen in Figure 1 the High Speed Line Multiplexor is a wired program computer which communicates with the timesharing system on the one side through core memory buffers and with devices on the other side through individual High Speed Line Units. Outputs of the High Speed Line Units can be adjusted to fit the needs of the attached data equipment.

For example, high speed graphic displays can be operated with 9600 baud serial asynchronous data output while remote multiplex computers require a 2400 band synchronous interface to a local data set. The remote multiplex computer then reduces the 2400 band stream to individual 110 band Teletype channels. A particularly difficult problem in this data communication network is an installation of a small number of terminals, say 2 to 8 in an elementary school. Most approaches to maintaining a data comm link of that length and cluster size seem very expensive in relation to the other costs involved.

One approach to this problem which IMSSS is now trying is the use of a duplex satellite channel and a low cost ground station for the data communication link between Stanford and an elementary school at Isleta Pueblo, New Mexico. Figure 2 diagrams the use of ATS-3 on a duplex communication channel. The data signals involved are frequency shift keyed analogues of the voltage mode teletype signals in a 500 to 3000 Hz band.

RF transmission uses the GE MASTR ground station with a power output of 350 watts and is in the 2 meter band from 136 to 149 MHZ. Yagi antennas have been used in single, dual, and quad configurations as well as a single helix.

At this writing the system is not fully operational. Factors contributing to the present status include half power mode operation of the satellite, limited satellite time available for testing, receiver desensitization, antenna pattern and pointing, antenna loading, polarization variables, spin stabilization variable, and random problems that are not understood.

There does not, however, appear to be any reason why successful operation can not be achieved. Calculations show a theoretical S/N of about 24 db for this link. On rare occassions this has been approached. Typical S/N figures range from 12 to 17 db. The link should be in regular operation (1-1/2 hrs per day) by early spring of 1972.

In conclusion we would to mention the relationship between our experiment with the ATS-3 and our longer term efforts to provide students with interactive instruction at reasonable costs. In an earlier paper--Jamison and Ball [1971]--we examined the conditions under which satellite distribution of CAI would be cost-effective with respect to commercial phone distribution. As one would expect, satellites appear cost-effective only when terminals are highly dispersed and at reasonably large average distances from the central computer facilities--more than 300 to 500 miles. These conditions are met if one wishes to utilize the flexibility, curriculum diversity, and economies of scale of a large computer and if the dispersion of CAI with time is somewhat geographically homogeneous. Thus in the evolutionary stage between the present time, where there is virtually no operational use of CAI, to the time when it is a standard part of every student's education there would appear to be an important potential role for satellites. Our present experiments are aimed at increasing our understanding of that role, and at gaining experience with the problems that must be resolved before an operational system is possible.

Reference

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(Figures on next page.)

Figure 1

Data Comm at IMSSS

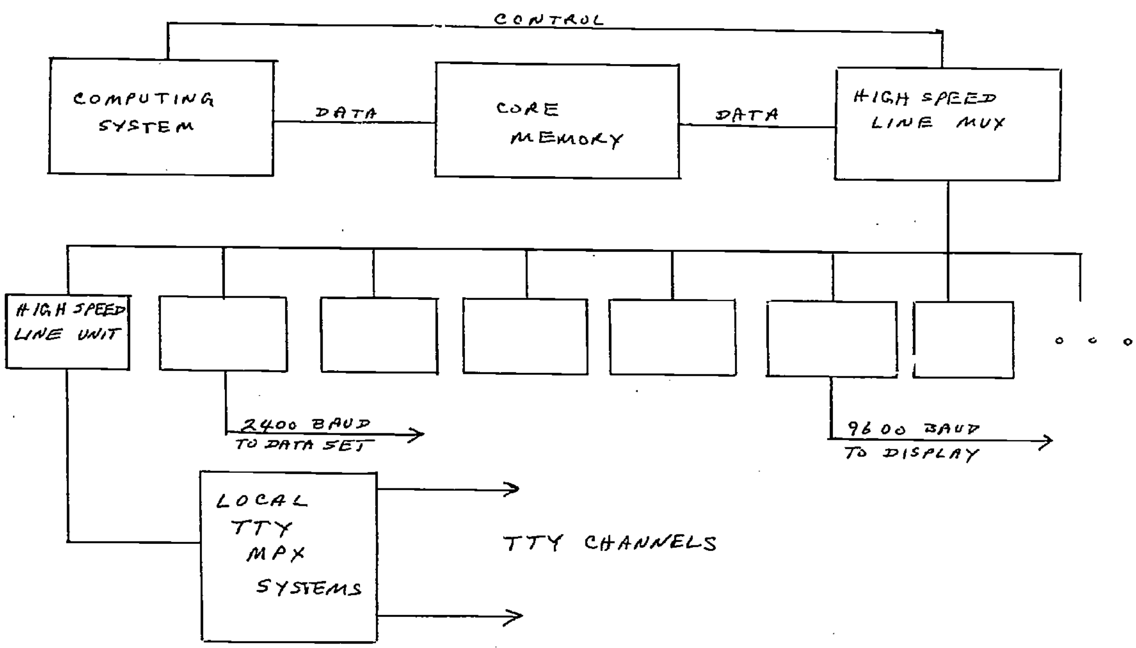
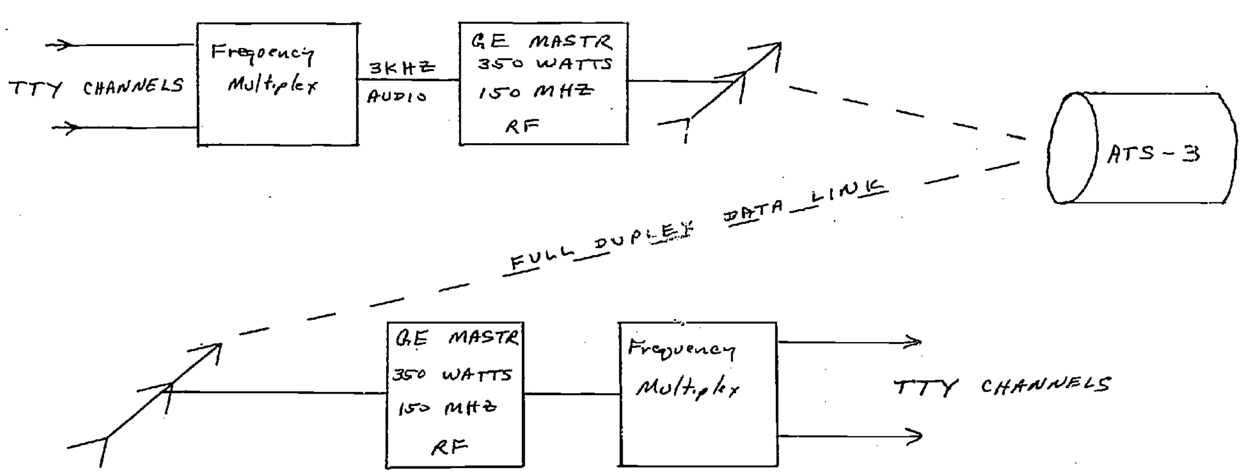


Figure 2

Sat Channels at IMSSS



INSTANT RETRIEVAL TELEVISION: FROM THEORY TO SYSTEM

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Introduction

Computer communications in North America is currently undergoing a revolutionary change which is reflected in the title of this conference. Recent examples of events accelerating this change include:

- the FCC computer communications inquiry
- the "Rostow" commission
- the Telecommission in Canada
- the Carterphone decision
- the birth of specialized common carriers
- development of digital networks
- the Canadian Computer/Communications Task Force
- the development of powerful, low cost mini and small computers
- increasing attacks on "fortress I.B.M."

These events have impacted mainly on two aspects of computer communications. They will result in a significantly changed structure of the industry and its regulation. There will also be significant increases in the type and quantity of computer communications capabilities available through the rapid introduction of newer technologies and new entrants into the industry.

All of these changes have been debated in recent years in many public forums and their prominence has tended to overshadow another aspect of rapid change in this field. This is the changing character of computer communications system applications. Until recently most systems consisted of automating or speeding up an existing operation by fitting the applications to a few basic models. We are now rapidly reaching the point where systems applications can be designed around the user's requirements and not around the available technology.

User Needs Research

The revolution in system applications will not arise only from changing technology but also from a better understanding of user requirements. This understanding can only develop through new forms of research and analysis. This includes basic research using theories of the utility of communications systems and it also includes research into future systems requirements. This paper overviews some Canadian research in these areas and described one system that has evolved from this type of research - Instant Retrieval Television (IRTV).

Communications Utility Theory

Gordon Thompson of Bell-Northern Research in Ottawa, Ontario has developed three measures of communications effectiveness. These measures are:

- the ease with which stored human experience can be accessed.
- the size of the common information space shared by the communicants.
- the ease with which the society using the system can discover and develop a plurality of new and fresh consensus (1) (2).

Thompson's research has found that the higher a system or technological package measures on these three scales, the greater its' benefit to its' users and the more widespread its' adoption amongst potential users.

Delphi Studies

Thompson's theory helps provide a means of evaluating new potential systems. The generation of applications concepts to test comes from various sources. One important source of concepts for Bell Canada has been a series of Delphi studies conducted by its Business Planning Group over the past three years. These studies have explored the future needs for computer communications and visual communications systems in the Educational, Medical and Business fields (3) (4) (5). A current study is examining the future of communications services in the home (6). This data provides further guidance in the development of potential applications systems. This work is oriented towards developing future systems. One system that has been developed and tested extensively in the past three years in Ottawa, Ontario is Instant Retrieval Television (IRTV - also known as Information Retrieval Television).

I.R.T.V.

I.R.T.V. is an educational system using a central Retrieval Center, housing a large (2,500-10,000 titles) library of visual material and a coaxial cable distribution system which is linked to television sets in individual classrooms or teaching areas. A teacher can order a title from a special classroom telephone and have it displayed immediately, or schedule it for a period later in the day or week.

The essential difference from normal E.T.V. systems is that the user (teachers and students) can utilize a large bank of material on demand. They control the system. They do not have to organize their activities around the system's schedule.

System Evaluation

When the system is evaluated using Thompson's measures it rates highly on all three scales. The Delphi panel has also predicted wide scale adoption of this type of system over the next 15 years. The students and teachers also rate the scheme highly and have been enthusiastic supporters of the three year experiment.

Conclusion

The development of Thompson's theories, the Delphi studies, and the I.R.T.V. experiment are good examples of how user needs research and development of practical user systems can be blended. Bell Canada, BNR, the Trans Canada Telephone System and selected users are currently cooperating to develop and trial other systems that utilize and refine this approach.

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EVALUATING COMPUTER APPLICATIONS

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Introduction

Previous papers in this session have discussed applications of computers and communications that may be characterized as experimental or still in the development stage. That they represent services of the future cannot be doubted. However, in assessing the likelihood of the extent of future applications one often finds it difficult to separate good ideas from marketable ones.

The objective of this paper is to attempt to put computer-communication services into perspective somewhat, by concentrating on on-going applications and derivatives or extentions thereof. This can be done in a variety of ways, for example, by identifying, classifying and enumerating various communities of users, by differentiating present from future applications, and by analyzing those communications media that are applicable to each class of services and/or users. Each of these is briefly touched on in this discussion.

User Communities

The spectrum of users of computers and communications now covers virtually every one of the major Standard Industrial Classifications (SIC codes) of the U.S. Department of Commerce. These range from agriculture and forestry, to durable goods manufacture, to wholesale and retail trade, to financial services, government, and so on. Many of the categories are represented only in a small way, being so far only minor participants in the new online, real time, remote terminal revolution. Other categories, however, such as transportation, banking and finance, and securities brokerage constitute industrial groupings that make up a large fraction of the total usage. (We do not ignore here the extent of the Federal Government's participation, particularly DoD and NASA. Our emphasis, however, is on commercial applications.)

In early 1968, approximately 60,000 data sets were in commercial service. In early 1970, this number had increased to 140,000 representing a growth of 50% annually. Such increases have continued, though at lower rates of growth, despite the 1970-71 business decline. At present, some 250-300,000 data sets are in service, increasing to about one million by 1975.

Overall, approximately the same number of terminals are in service as modems or data sets. Currently these also amount to about 300,000, and they are connected to some 8,000 to 10,000 general purpose computers through a great variety of network configurations and telecommunication links. Many of these computers have only a few terminals, and in some cases they are little used. In other situations, however, the terminals are an integral part of a real time information system that operates on "live" business data. Airline reservation systems, stock quotation systems, and certain banking operations are a case in point.

As an example of the extent to which computer-communications can permeate business activities, we refer to a previously compiled list of some 300 potential data transmission applications classified by industry.[1] Table 1 summarizes this list, giving the number of potential applications identified for each industrial grouping. Table 2 illustrates some of the applications.

Table 1
Potential Computer-communication Applications Identified by Industry

Industry	Number
Banking	24
Insurance	10
Law enforcement	17
Library services	21
Education	18
Investment and securities brokerage	24
Manufacturing	18
Printing and publishing	13
Petroleum and industrial chemicals processing	14
Wholesale and retail trade	15
Utilities	32
Transportation	
Air	19
Rail	19
Highway	18
Medical/health	18
Personal services	
Travel	6
Sports/entertainment	4
Home communications	6

Table 2
Example Applications

Banking
- Demand deposit accounting
- Savings accounting
- Mortgage accounting
- Credit card accounting
- Loan accounting
- Credit authorizations
- Account balance inquiry
- Online customer services
- Online transaction entry
- Automatic loan payments
- Lock box remittance

Library services
- Remote browsing
- Interlibrary loans
- Automatic cataloging
- Research and location of material
- Answering reference questions
- Distribution of reading lists
- Access to documents at remote locations

Education
- Instruction
- Instructional management
- Testing
- Counseling
- Administrative planning
- Connecting remote campuses
- Placement service
- Fiscal accounting and reporting
- Computer assisted instruction

Present versus Future Applications

In this paper we are limited to giving only brief examples of the difference between present and future applications. These should illustrate two points, however, namely that one needs, on the one hand, to be cautious about projecting developments in certain (public) application areas, yet on the other hand not timid in assessing the likelihood of developments in commercially acceptable projects.

A case of the latter may be found in commercial banking. At the present time, the bulk of the computer transactions taking place here are accomplished in a batch mode, and this applies whether or not communication links are used. That is, most banks with geographically dispersed branches transmit data "in bulk" via high speed links (19.2 or 40.8 kilobits per second), process it remotely, then return the computed results in a similar manner. In California, where statewide banking is allowed, this practice has led to the use of leased Telpak channels that, for the most part,double as voice lines as well as data channels.

What is new on the banking scene is online, real time, transaction-oriented processing. While such activities have been underway for some time in mutual savings banks and savings and loan institutions (at present, between 15,000 and 20,000 terminals are installed in such locations), real time operations are still in the future for most commercial banks. Thus, while demand deposit accounting is the first and most obvious application that one would like to implement, the difficulty of doing so on a large scale poses severe problems. Nevertheless, this kind of computer-communication is inevitable and indeed is already occurring on a small scale, as for example at Pacific National Bank in Tacoma, Washington. Here, Courier terminals--one terminal for each two tellers--are being used to access online customer files for inquiry as well as "store and hold" updating, for both deposits and check cashing. At a later date, the growth of a direct funds transfer system (the cashless society) is entirely feasible and some observers are predicting it to be substantially in being by the end of the decade. Indeed, the acceptance of magnetic ink character recognition (MICR) was adopted surprisingly swiftly, there being an elapsed time of only eight years between initial use and 95% adoption of the technique.

In contrast to the above, one may take the classic example of computer assisted instruction. While the potential of CAI has been pursued vigorously for many years, its development to this time has depended largely on public funding, institutional grants, and so on. Thus, at this juncture one cannot say with certainty that its full development is inevitable. One can say that it is desirable, however, if he chooses to do so, and I do.

Transmission Media

It is in this area that much controversy has been generated. The fact that the telephone network was "initially designed for voice transmission" has led many observers to conclude that it cannot--even will not ever--be used effectively to transmit data.

The facts of the matter significantly contradict such conclusions, however. First of course is the simple illustration that data is (are?) transmitted over the voice network, all day, every day, and with useful results. Despite all the hand wringing over noise, errors, signaling, connection time, limited transmission speed, and so on, a recent survey of large telecommunications users, both voice and data, revealed only a small sampling of dissatisfied telco customers. The majority, surprisingly enough, have had excellent results, except of course in New York City where everything, including telephone service, is in serious difficulty. Naturally these customers would like to pay less for their service, but that is a separate issue from service satisfaction.

Of greater significance than present-day usage, however, is the situation likely to obtain in the future regarding transmission media. Here, the variety of potentially competing systems are important, such as fully digital networks (e. g. Datran), other specialized carrier microwave systems (MCI et al), cable television, and satellites.

It is the author's contention that most uses of computers and communications for at least the next 15-20 years will take place over the telephone system. The reasons for this argument are as follows. First, it can be shown that the volume of transactions to be expected over such a time period is significantly less than the capacity of the network as it may be expected to develop. Second, present uses of the network are for the most part extremely inefficient. This is changing gradually as users become more sophisticated in designing their own computer networks which, in turn, use telco links for transmission. An example here is the expanding use of minicomputers for data concentration and front ending. Third, most large users do not lease lines for the exclusive use of data transmission. Rather, they use these lines in an alternate voice/data mode, often transmitting data at night and using the lines for voice transmission during the day. In this way, data transmission comes along for no more than the cost of modems and associated equipment, excluding the cost of leased lines. Finally, one cannot overlook the ubiquitous nature of the telephone system--it is not only "there," but here, there and everywhere as well. Such coverage of the nation cannot in any way be duplicated without spending extraordinary amounts of money, regardless of the fact that new (particularly digital) technology reduces significantly the investment required per bit transmitted.

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COMPUTER COMMUNICATIONS APPLICATIONS IN THE U.S. POSTAL SERVICE

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The United States Postal Service is the largest single business organization in the world, and daily processes almost as much mail as the rest of the world combined. If the system were to stop for one day, every citizen and business in the country would be affected. Unlike other business organizations that can stop production or cease operation for extended periods of time without adversely affecting the nation, the Post Office Department cannot. For example, over 30 million people depend on the Post Office to deliver their monthly Social Security or retirement checks. To provide dependable service for this ever-increasing tide of mail requires that the Postal Service modernize and become more efficient.

However, the utilization of technological advances in postal long-range planning has been minimal; research and development on applicable methods and equipment to speed mail processing and reduce handling costs have been almost non-existent, until recently.

The Postal Service utilizes three systems to transmit data between major post offices, Postal Data Centers (PDC's), Automatic Data Processing Centers (ADPC's), USPS Headquarters, and special activities. One is the Postal Source Data System (PSDS) network which interconnects major post offices to two ADPC's through four teleconcentrator points. The network consists of a variety of communication terminal devices linked to Control Data Corporation computer equipment using AT&T and Western Union transmission facilities. Eighty cities are connected by 110,000 miles of dedicated full-duplex 2400 bps lines. Over 8,000 terminal devices, such as transacter consoles, badge readers, and electronic weight scales are on line to five teleconcentrator sites equipped with dual CDC 1700 computers. The five sites feed into the two ADPC equipped with dual CDC 3300 computers.

Another smaller network of magnetic tape terminals transmits data between USPS Headquarters, six PDC's and two ADPC's via Digitronics equipment and dial up voice grade AT&T common carrier transmission lines (203 A modems).

The third network connects two supply centers in support of the realty logistic management information requirements of the U.S. Postal Service. This network utilizes Mohawk magnetic tape equipment terminals with conditioned, dedicated AT&T network facilities (201 B modems).

The systems have been very costly and have been plagued with technical problems since their inception. An RFP was issued to industry by the U.S. Postal Service on August 21, 1970, entitled Digital Communications System Survey. Its purpose was to analyze and evaulate the present Postal Service digital communication facilities and project what facilities will be needed in five years. It was also to develop alternative systems that will prove cost effective, and recommend an integrated digital communication system along with a time phased plan for implementation. The solicitation was suspended and subsequently cancelled as a result of a GAO report.

The most significant endeavor taken by the U.S. Postal Service to take advantage of technological advances in computers and telecommunications has been their interest in an Electronic Mail Handling System.

The objective of an electronic mail system is to take advantage of the new techniques in the fields of computers, data processing and transmission, automatic controls and communications and apply them to the postal system. The result would be to handle mail more efficiently and to increase the productivity of postal employees.

An electronic mail system processes mail in electronic form rather than handling paper as in the present postal system. Instead of transporting a letter that contains hand or machine printed data, the letter contents are transformed into an electrical signal by means of input conversion equipment. Sorting and transportation functions are effected by switching and transmission equipment that direct the letter data to a destination post office. The address of the letter would be used to select a path through a nationwide communications network that would accept the electrical data and direct it to the destination postal facility. Output conversion equipment then prints out a replica of the original letter onto paper that is subsequently delivered to the addressee.

Some mail processing functions, however, would gradually change to accommodate new developments, while others would be developed to handle new types of mail. For example, computer-generated mail such as credit card billings, nationwide advertising and mailing lists, and checks that reside on computer magnetic tapes can be transmitted over telecommunication lines to sectional center facilities. These would then be put into hard copy form first, and placed in a mail system at a single central facility as is presently done.

The goal of an EMH system is nationwide next day delivery. However, electronic mail offers the user other advantages, such as direct access to the system for immediate mail transfer. For example, where large volume mailers want timely individual delivery, EMH could provide input conversion and hard copy output equipment with network link connections directly to the patron's facility, thus providing direct access to the nationwide EMH network.

In summary, having been under various funded contracts with U.S. and Canada Post Offices over the past two years the conclusions and recommendations made in the first Electronic Mail Handling Study are still valid today. These are:

1. <u>Construction of a Nationwide Electronic Mail Handling System is Technically Feasible</u>

The United States is in the midst of a dramatic phase of technical growth. The advances made in areas of data processing, transmission and control have been particularly significant. The purpose of the first five work tasks of this study was to assess these advances and the equipment presently available to determine if the implementation of an EMH system is technically feasible. The result of this effort was that in some instances present equipment is inadequate, however, the technology does exist to develop equipment of sufficient capability.

2. It Was Recommended that a System Study be Performed to Obtain a Cost Effective Configuration for an EMH System.

The overall objective of the study (which is currently in progress) is to determine if an electronic mail handling system can provide dependable mail service at a reasonable price. Before a system can be developed to handle mail electronically, a model of its inputs, outputs and traffic demands is being generated. The model will provide the data necessary to define preliminary system configurations and equipment requirements. An analysis will then be performed to synthesize a system that is optimized with respect to cost. The outputs of the study will include:

A. The configuration of the system's collection, distribution and delivery network.

B. A hierarchy of postal collection centers.

C. The equipment required to process the mail in each type of center.

3. It was Recommended that a High-Speed Facsimile Equipment be Developed Especially for Electronic Mail.

Existing facsimile equipment is too slow to handle the anticipated electronic mail volumes. Most equipments are designed to operate at scanning speeds compatible with a telephone line or other common carrier channel. The wide bandwidth channels used for electronic mail transmission will permit faster conversion, so suitable high-speed facsimile equipment should be developed. More rapid facsimile conversion can be achieved by employing data compression methods to the signal output from the scanner. Data compression permits better utilization of the transmission channel bandwidth so conversion times can be reduced and therefore result in more economical conversion.

A study into methods and application of data compression to facsimile signals should be initiated. Typical facsimile scanning procedures do not permit generation of a digital address. The address must be either entered separately or recognized from the facsimile scan signal. At high thruput rates separate manual entry would be impractical and automatic entry methods must be employed. An evaluation of suitable address insertion techniques should be made and appropriate equipment designed.

4. A Study of Paper Handling Techniques was Recommended.

Most mail suitable for electronic handling will be collected and delivered in the form of paper. Prior to input conversion envelopes may have to be opened, the letter removed, unfolded, faced and stacked. Automatic paper handling equipment must then feed each page to the conversion equipment and transport it through the reading area to an output stacker. The equipment may have to accept letters that vary in thickness, size and quality. Folds, creases and tears could cause two pages to be fed at one time or result in jamming of the transport mechanism.

The technology of high-speed paper handling is not well documented; experience seems to be the most useful factor in designing equipment that will operate reliably at high speed without jamming. For this reason, we recommend a study to evaulate the problems of high-speed paper handling techniques. The study should examine the problems of high-speed paper handling and make recommendations on methods appropriate for handling electronic mail. The study should also determine whether a special form or envelope should be used for electronic mail.

5. Optical Character Readers are Currently not Suitable for Electronic Mail Conversion.

Optical Character Recognition (OCR) equipments presently used in business applications have not been designed to read the variety of print and type styles that occur in letter mail. OCR's used by the Post Office for reading addresses from letters give satisfactory performance but have error rates in excess of those acceptable for electronic mail conversion. Experimental readers not yet in production claim to be capable of reading any machine-printed material. However, these readers are expensive and not considered fast enough for electronic mail conversion.

6. A Special Purpose Switching System Must be Designed to Sort, Route and Control Electronic Mail.

The switching function is the most complex part of an EMH system. Switching equipment is used to sort, route and control the flow of electronic mail. Efficient processing will depend upon the use of high speed switches, digital computers and data transmission equipment in a nationwide network. These equipments are presently available but a switching system must be designed to satisfy the special requirements of electronic mail.

7. Transmission of Electronic Mail can Be Accomplished with Presently Available Equipment.

Advanced communication techniques presently employed in data transmission by microwave radio, coaxial cable and satellite can be utilized in an electronic mail handling system. The military and telephone transmission capabilities are examples of systems that feature bandwidths compatible with estimated electronic mail needs. Moreover, the data handling capacity of transmission facilities promises to increase at a faster rate than the predicted electronic mail volume.

8. Privacy of the Mail During Transmission is Virtually Assured by the Technical Complexity of Transmission Methods.

The sanctity of the United States mails is presently maintained by tradition and postal laws. The mark of an uncompromised letter is an unopened envelope. An electronic mail handling system has no such symbol of security. However, mail in electronic form will offer a privacy safeguard without regard to honesty or personal integrity. The reason is that the complex modulation techniques used in transmission facilities requires that a potential intruder possess considerable technical capability. In addition, the cost of the equipment necessary to intrude on these advanced systems is beyond the means of most individuals.

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COMPUTER TO COMPUTER COMMUNICATIONS
VIA SATELLITE DATA LINK

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Digital data communications at ever increasing rates are being used to convey all forms of information. For years this technique has been used in telemetry systems for gathering information on the status of rockets during launch and in flight to their target, on earth-bound satellites manned and unmanned, on deep space satellites and for uncounted other uses.

The use of digital computers to solve a seemingly endless variety of problems, has similarly enjoyed a tremendous diversification and growth. In order to function usefully, a computer system must be given information upon which it can operate to develop the desired output. This computer input normally takes the form of paper tape, punched cards, magnetic tape data or some other digital data form. Even in those cases where the data exists in some analog form, the first operation performed on the signal is to digitize it thereby converting it into a form acceptable to the computer.

Noting the proven and accepted use of both digital computers and digital data links, it is not surprising that their joint use should be considered. This is especially true when several large, mutually remote, computer facilities have need to exchange large quantities of data. The need and advantages of high-rate digital communications between computers can be easily demonstrated. A standard 14" tape reel operating with seven tracks and a bit packing density of 800 bpi contains approximately 10^9 bits of binary data. There are two ways of getting this data from one user facility to another: the tape reel can be hand carried (physically transported) or the data can be transmitted via a communication link. In recent times, transmitting data at high rates has been taken to mean transmittingat 2400 bps. Operating at this rate, transmission of a single complete reel of tape requires one hundred hours of continuous transmission time! If communication could be established at 50 Kbps or 1.8 Mbps this transmission time could be reduced to one hour and to three minutes respectively. Communication system equipment able to provide computer to computer data transfer at these rates has been developed by Philco-Ford Western Developement Laboratories and is the subject of this paper.

The overall operation to be performed is to read a magnetic tape, transmit it and reproduce it at the receiving facility in its exact original form. Deceptively simple though it sounds, three separate data processing problems must be solved to successfully develop such a communication system. First the entire tape data and format must be converted to a form recognizable by the receiving equipment so that it can regenerate the original tape. Secondly, the computer appears to the outside world to be an asynchronous, 16-bit parallel data source. Digital communication systems must be synchronous to maximize communications efficiency and, furthermore, generally require a serial data source. Finally, the data to be transmitted must be received error free. All communication links make errors. The goal of this system was to achieve a bit error rate (P_b) of no more than one error in 10^{10} transmitted data bits, i.e. $P_b \leq 10^{-10}$.

The equipment developed by Philco-Ford WDL utilized Honeywell 516 computers operating with Honeywell tape machines. A special-purpose Interface Unit and high efficiency triple-error-correcting Threshold Decoder developed by Philco-Ford provide: (a) the asynchronous to synchronous conversion, (b) parallel to serial conversion, (c) the data formatting and (d) the high efficiency, low-error-rate operation of the link. Another very important feature provided,which can only be fully appreciated when working with an operating system,is a very efficient and easy to use software system. Efficiency is measured here in terms of data processing speed and of maximum simplicity in terms of demands placed on operator educational requirements. To complete the communication system Philco-Ford WDL has off-the-shelf data modems capable of operating within 0.5 dB of theoretical biphase-shift keyed (BPSK) performance. Use of a Philco-Ford BPSK modem, together with the other above described equipments, a complete computer-to-computer high rate link can be implemented. Typical performance characteristics for the system are presented in Table 1 assuming the use of a 40 ft. ground terminal and operating through an IDCSP satellite (1).

A system similar to this has been implemented by Philco-Ford WDL and was previously described in the literature (2). The realization of this system must not be looked upon as a special, one-of-a-kind, type of situation. The need for computer-to-computer communications is growing and will become, in the near future, an ever-growing need clamoring loudly to be satisfied. The advantage of satisfying this need via a satellite communication link is not only that it performs the task well but more economically than other available means, e.g. ground based common carrier.

TABLE 1

PERFORMANCE CHARACTERISTICS OF A TYPICAL COMPUTER-TO-COMPUTER LINK OPERATING THROUGH A 40 FT EARTH TERMINAL AND IDCSP SATELLITE

DATA RATE - Kbps	50	56.25	112.5	225	450	∞
BIT ERROR PROBABILITY C/kT > 67 dB (Hz)	$< 10^{-15}$	$< 10^{-15}$	$< 10^{-15}$	10^{-14}	3×10^{-10}	
2400 FT REEL TRANSFER TIME (MINUTES)						
556 bpi, 36 ips	41.0	36.6	18.2	13.3	13.3	13.3
800 bpi, 80 ips	55.8	49.7	24.8	12.4	6.4	6.0
800 bpi, 150 ips	55.8	49.7	24.8	12.4	6.4	3.2

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TRANSMISSION CONSIDERATIONS BETWEEN SWITCHED SERVICE AND PRIVATE LINE DATA COMMUNICATIONS

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INTRODUCTION: The purpose of this presentation is to provide designers and users of data communications service with an understanding of the two basic telephone communications services, the DDD Network and Private Line.

The DDD Network provides the electrical transportation of customers' messages from one location to another. Switching includes identifying and connecting independent transmission links to form a continuous path from one terminal to another.

The simplest connection involves voice frequency transmission between two stations through a single switching office. More complicated connections may involve many links in tandem and include several switching offices.

The Transmission paths in the network may be divided into two categories, station loops and trunks. The station loop is normally a voice frequency facility using a telephone cable pair and is dedicated to the use of an individual station. The loop provides a two-way path between the customer's terminal equipment and the local central office. The loop is usually the largest single investment directly associated with a particular station. Economical loop design is thus of primary importance. While loops are dedicated to an individual customer, trunks are shared by many customers and provide transmission links between switching offices.

SUBSCRIBER LOOP AND TRUNK CONSIDERATIONS: The optimum design of the local loop is of considerable importance. Two loops are a part of every telephone connection so their electrical performance can have a strong influence on the transmission quality of the service we provide. The selection of wire sizes and loop lengths is based on loop resistance and a set of rules which take into account the correlation between resistance and attenuation.

Rules Affecting Loop Design:

a. Select the most economical (smallest) gauge, or combination of consecutive gauges, permitted by the conductor resistance range of the central office.
b. Provide loading on all loops longer than 18 kilofeet. From the standpoint of transmission and economic design, the H88 loading system is usually the most attractive.
c. Limit cable bridge tap to 6000 feet.

Very long suburban loops present a special problem. Meeting the office resistance range at the end station may require considerable coarse gauge cable. An economic balance must be struck between a cheaper high resistance loop and the expense of extending the office range.

The impedance of a local loop terminated by a telephone set varies as a function of frequency, cable design, and loop length. Theoretically, these impedances could be adjusted by the inclusion of suitably designed networks, but this is economically unattractive because each loop would have to be so treated. Individual loops, which may have different impedances, are connected by end-office to trunk facilities, which may also have different impedances. However, there are fewer trunks and their costs are shared by many customers. Control of trunk impedance is therefore more economical; precision networks and impedance compensating networks of various designs are provided for this purpose.

Intertoll trunks are designed to provide good impedance matches at their terminals and at intermediate points. Furthermore, intertoll trunks generally introduce no appreciable frequency distortion. Thus the attenuation of an intertoll trunk usually determines its contribution to the effective loss of a circuit. In the exchange plant, loops and trunks are normally electrically short and, as mentioned earlier, do not have particularly good impedances at junctions. Thus, the impedance at a particular point of a built-up connection will depend on the impedance terminations at remote points. Likewise, the power loss will be a function of the attenuation of the components and the reflection gains and losses at the numerous junctions.

NETWORK: The telephone systems in the United States and Canada handle more than fifteen million long distance messages a day. These are routed over a comprehensive network of more than 300,000 long-haul trunks which interconnect about 1,600 long distance switching offices. This network serves, with few exceptions, all of the telephones in these two countries and provides for establishing connections to most other parts of the world.

Large volumes of traffic between any two points are generally routed most economically over direct trunks. When the volume of traffic between two offices is small, however, the use of direct trunks is usually not economical. In these cases the traffic is handled by connecting together, by means of switching equipment at intermediate offices, two or more trunks to build up the required connection. The places where interconnections are made are generally known as "switching centers". "Built-up" connections may involve several switching centers if the originating and terminating locations are a great distance apart. It is important that telephone plant be designed to provide a constant quality of transmission and service for this multiswitch traffic as well as the large volumes of traffic handled by the less complex direct and single switch connections.

The needs of distance dialing are met by switching and trunking arrangements that employ hierarchical routing discipline and the principle of Automatic Alternate Routing to provide rapid and accurate connections, while making efficient use of the telephone plant. The hierarchical routing discipline provides for the collection and distribution of traffic, and permits complete interconnectability of all offices. With the Automatic Alternate Routing principle, a call which encounters an "all trunks busy" condition on the first route tested is automatically "route advanced" and offered in sequence to one or more alternate routes for completion.

Under the Switching Plan each office involved in the completion of long distance calls is classified and designated according to its switching function, its interrelationship with other switching offices, and its transmission requirements. The class designations given to the switching centers in the network determine the routing pattern. Figure 3 illustrates how various classes of offices might be grouped. The office classifications, their functions, and the switching areas they serve are described in the following paragraphs.

The central office equipment entities where telephone loops are terminated for purposes of interconnection to each other are called "End Offices" and are designated as "Class 5" offices.

The switching centers which provide the first stage of concentration for inter-toll traffic from end offices are called Toll Centers or Toll Points and are designated as "Class 4". Certain switching centers, in addition to connecting end offices to the network, are selected to serve as higher ranking switching centers. These are Primary Centers, designated "Class 3"; Sectional Centers, designated "Class 2"; and Regional Centers, designated "Class 1". Collectively, the Class 1, 2 and 3 offices constitute the Control Switching Points of the distance dialing network. Each separate switching unit must be assigned its own classification within the hierarchical routing plan.

It is not necessary that Class 5, 4 and 3 offices must always home on the next higher ranking (lower class number) office. For example, Class 5 offices may be served directly from any higher ranking office, Fig. 3. Direct high usage trunks are provided between offices of any class wherever the volume of traffic and economics warrant the necessity. High usage trunk groups carry most but not all the offered traffic in the busy hour. Overflow traffic is offered to an alternate route.

There are four simple rules that govern the routing of a call, see Fig. 3: (1) Never use more than two chains. (2) Never go up a foreign chain. (3) Never go down the local chain. (4) Always take the shortest available route. It should be noted that the maximum number of trunks connected in the final route chains from Class 4 office to Class 4 office cannot exceed seven for intracountry calls or eight for a very few United States-Canada calls. These plus the trunk to the Class 5 office at each end, result in a maximum of 9 trunks in tandem for intracountry calls and occasionally 10 for United States-Canada calls. The probability of a call traversing all possible trunks of the final routing chains is estimated to be only a few calls out of millions. Calls between high volume points are completed on direct trunks regardless of distance; relatively few encounter multiple switches. As traffic growth occurs, a relatively larger portion of the traffic is carried on direct routes. Multiple switching is the rule, however, between infrequently called locations.

ALTERNATE ROUTING: The successful completion of long distance traffic depends upon a high-speed trunk network so that "all trunks busy" conditions are rarely encountered. Alternate routing is one of the techniques that makes this possible with reasonable trunk efficiency. A call entering the network is always routed over the most direct available trunk. When the first choice high usage trunk group is busy, a call will be alternate routed to other trunk groups. In the example shown in Figure 3 there are 13 possible routes for a call from Station A to Station B. Only when all high usage trunk groups are busy will a call be routed over the final trunk route.

VIA NET LOSS CONCEPTS:

Design Factors: The following transmission considerations are important in determining the lowest practicable losses at which trunks may be operated:

a. Echo
b. Tolerance to Echo
c. Singing

Echo: Echo is the sum of all the transmitted energy which has been reflected back to its source. Fig. 1 shows how an echo arises on a telephone connection. This figure shows the relatively simple case of a 4-wire trunk connected by means of 4-wire terminating sets to a 2-wire termination through the switches at each end. The 2-wire terminations may be anything from nearby telephone sets to sets on a wide variety of customer loop lengths on loaded or non-loaded facilities, or on carrier systems. There may also be intervening trunks on cable (either loaded or non-loaded) or on carrier systems. The range of impedance presented by these terminations varies widely, being different for each connection. The best that can be done under such circumstances in selecting a balancing network for a 4-wire terminating set is to choose one which is the best compromise for the range of conditions encountered. This is known as a compromise network. It consists of a resistor and capacitor in series whose values are determined by the general level of impedance of the particular office. Understandably, the balance in any given connection might not be ideal.

When the customer at Point A talks, his speech energy (the heavy solid line) travels along the circuit to Point B and on to the distant customer. However, because of the impedance mismatch between the local plant and the compromise network at Point B, some of this energy (the dash-dot line) is reflected back across the 4-wire terminating set and is transmitted back to the talker's receiver. Thus he hears his own voice and, if the time required for his speech to travel to Point B and back is long enough, the returned energy appears as a distinct echo; hence, the term "talker echo". The round trip delay (usually expressed in milliseconds) is the time it takes the energy from the speaker's voice waves to travel to the distant end of the circuit and back again. Both the magnitude and delay of the energy affect the tolerance level of the echo. The greater the delay, the less echo level the talker can tolerate.

At Point A, the same kind of impedance is present as at Point B. Consequently, some of the talker echo arriving at Point A is again reflected back across the 4-wire terminating set at that point and is transmitted back (the dotted line) to the subscriber at Point B. This is known as "listener echo". However, the extra loss across the 4-wire terminating set at Point A and the added loss encountered in the additional trip down the circuit so attenuates the listener echo that it is usually not controlling in this type of connection. For data transmission talker echo has no effect on the data transmitter, but listener echo can be extremely detrimental to the data receiver if the echo level is high enough and the delay long enough.

The echo characteristic of a connection as discussed above imposes a lower limit on the loss at which a trunk can be operated. Thus it is the trunk loss itself to which we must look to control echo. The performance objective for talker echo (customer to customer) is as follows: The design of trunks should be such that talker echo will be satisfactorily low on more than 99 percent of all telephone connections which encounter the maximum delay likely to be experienced.

Singing: Referring to Fig. 1 again, it can be seen that if the current returned to Point B by the "listener echo" path is greater than the original current arriving at that point, a condition is set up which sustains a circulating current around the loop consisting of the two sides of the circuits and the terminating sets at the ends. This condition can arise at any frequency due to low return losses at Points A and B and higher gains in line repeaters or carrier channels. Stated in another way, singing occurs when, at any one frequency, the sum of all the gains in the transmission paths exceeds the sum of all losses. Singing can be prevented by limiting repeater and carrier system gains and, preferably, by improving the terminal return losses.

VIA NET LOSS (VNL) DESIGN: It is desirable to assign the overall loss so that each trunk of a connection operates at the lowest possible loss consistent with echo and singing requirements. This is accomplished through the use of echo suppressors and VNL design. The VNL design plan was arrived at by first considering the tolerance of customers to talker echo, then taking into account the statistical variations of the elements involved, and from this determining the loss required between end offices in an overall connection. Loss per trunk requirements are obtained by allocating this overall connection loss among the number of trunks in the connection.

Figure 2 shows the design loss to satisfy echo and singing requirements as a function of the number of trunks to be connected in tandem and the round trip delay of the facilities. Inspection of this figure reveals that as the number of trunks is increased, an increase in loss of approximately 0.4 dB per additional trunk is required. This increment compensates for the increased loss variability with an increased number of trunks. The minimum loss of 4 dB is required to prevent a singing condition at low time delays. Most long-haul carrier systems have a propagation time of about 0.007 milliseconds per mile. To estimate the round trip delay of a connection the propagation time should be multiplied by twice the one-way connection length.

Via net loss design rules are only used when the round trip delay is less than 45 milliseconds. This is done to limit the maximum trunk losses so that the nominal received power is adequate. When the round trip delay exceeds 45 ms, a trunk is equipped with an echo suppressor and operated at zero loss. Fig. 3 shows the objective losses for trunks in the switching plan. These objectives provide a satisfactory compromise between: (1) the need for sufficiently low loss to provide natural received volumes and minimum contrast in received volumes on different calls, and (2) the need for sufficiently high losses to ensure adequate performance from the standpoint of talker echo and near singing. These are the objectives obtained by Via Net Loss (VNL) design considerations.

PRIVATE LINE SERVICE: An alternate mode of operation from the DDD network is Private Line. Although the facilities used to provide the data channels are the same as those found in the DDD, control with regard to choice of facility and routing is available to the telephone company design engineer. Because the choice of route and facilities can be predetermined, so can the overall transmission characteristics. Appropriate equalization is administered as required. The user states, at the time of placing his order, the parameters he desires. The worst case condition with regard to overall circuit characteristics can be found in the Bell System technical reference manual entitled "Transmission Specifications for Voice Grade Private Line Data Channels".

Should the data user desire, the Private Line data services can be ordered with certain limitations, on a two point, multipoint, or switched basis. The limitations are based upon the degree of equalization required and the number of points involved.

DATA SERVICE PLANNING: Data service planning involves the evaluation of specific user requirements and the consideration of many alternatives. Several areas of paramount concern in planning a data system are: volume of data, urgency of data, sensitivity to errors and the ability to handle interruptions. As these areas are fundamental to the data communications process they should be thoroughly evaluated prior to considering any specific implementation. Once this is done, attention can be directed toward finding a service or combination of services that fulfill the system requirements.

The switched network offers the data communications user considerable flexibility in terms of the widespread availability of connections and economical rates. Its limitations include the variability of performance from call to call, limitations on speed imposed by the voice bandwidth nature of the network and the time required to set up connections. Where these limitations are serious, it may be that other services are better suited to fulfilling specific requirements. These services include switched and non-switched voice grade private line services, several types of teletypewriter oriented data services and wide band data service. In planning a total data system, these other services should be considered as alternatives, depending on traffic and feature requirements, or they may be used in combination with switched network service.

Whether the data user elects to utilize Private Line or the DDD network for his communication link, it must be realized that the facilities involved introduce distortions. The term "window" has been used to describe the transmission medium. It may be a window indeed, but it is not without imperfections. It contains delay, both absolute and envelope, loss, non-linear loss vs frequency, white noise, and impulse noise, as well as possible phase jitter, frequency off set and occasional hits due to microwave switching.

ECHO PATHS

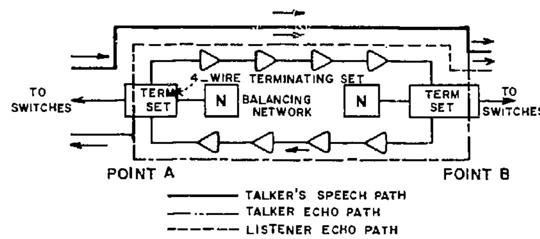

FIG. 1

RELATIONSHIP BETWEEN OVERALL CONNECTION LOSS AND ECHO PATH DELAY
(CLASS 5 TO CLASS 5 OFFICE)

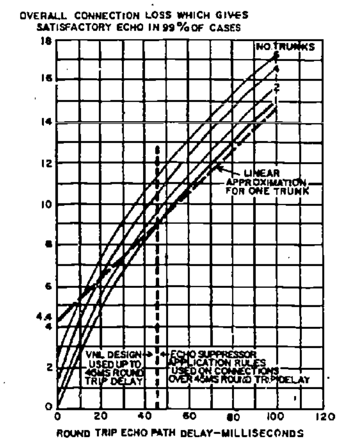

FIG. 2

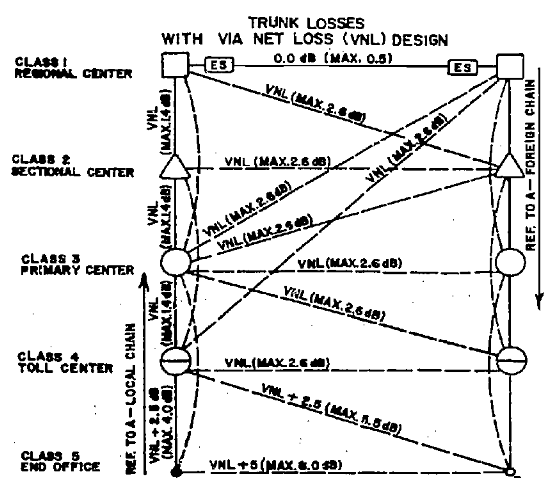

FIG. 3

Cost Effectiveness Evaluation of Concentrators in Data Communications Networks

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The Problem

Concentrators are employed in data communications networks for the primary purpose of reducing line charges in long-line networks. This advantage must be weighed against the increased thruput and lower terminal response time provided by the more expensive point-to-point network. Concentrators perform the function of multiplexing multiple input lines onto one or more higher speed output lines. In addition, concentrators provide capabilities for message assembly, code conversion, editing, formatting and bufferring. Concentrators may be either hard-wired or programmable. Hard-wired concentrators have fixed sample time, number of samples, number of lines, input rate, message size, etc., while programmable concentrators are frequently mini computers in which the above parameters can be varied to a considerable extent. In addition, programmable concentrators can perform message accounting, traffic analysis, billing, dynamic buffer allocation, priority message processing and elaborate error control routines. Thus, programmable concentrators provide greater application flexibility but at higher hardware and software costs.

Techniques are needed for determining whether lines should be concentrated or routed on a point-to-point basis in a network in which user terminals are to be connected to a computer. Secondly, if line concentration is appropriate, it is necessary to choose between hard-wired and programmable concentrators. Both effectiveness and cost factors must be considered in this evaluation. From the point of view of the user at the terminal, response time is the most important quantitative performance measure. From a total network performance point of view, thruput is the most appropriate measure. Cost factors include the following for each of three network connection schemes:

	Point to Point	Hard-Wired Concentrator	Programmable Concentrator
.Modems	x	x	x
.Point to point line charges	x		
.Installation	x	x	x
.Concentrator(s)		x	x
.Input line(s)		x	x
.Output line(s) charges		x	x
.Software development			x

In this evaluation, the costs of terminals, transmission controller or front-end processor, and central computer are approximately the same for point-to-point and concentrator networks.

Approach

The approach which is employed is to develop queueing models of selected networks and to compare the effectiveness and costs of using concentrators with a point-to-point connection. The analysis consists of the following four phases:

1. Develop feasible networks for both concentrator and point to point networks.
2. Compute terminal response time and network thruput for the two types of networks.
3. Compute the total cost of the two types of networks.
4. Compare the effectiveness and costs of point-to-point with concentrated networks and determine which of the following is most appropriate:
   - point to-point connection
   - hard-wired concentrator
   - programmable concentrator

Phase 1 considers feasibility from two standpoints. One purpose is to develop networks in which the traffic intensities and queues in each part of the network are not excessive. The second purpose is to provide a network which satisfies response time and thruput requirements for specified number of terminals and input rates.

Next, (Phase 2), terminal response times and thruput rates are computed for each configuration and for various input rates. In the case of programmable concentrators, the effects on performance of factors such as priority message processing and buffer storage areas are evaluated. In Phase 3, feasible network total costs are computed for the alternate networks, considering the cost factors previously listed. Finally, in Phase 4, incremental response times and thruput rates are compared with incremental costs in order to select the most appropriate configuration. Curves of effectiveness versus cost for the three alternatives are presented.

Conclusions

When the number of user terminals can be varied for a fixed message input rate, the point-to-point network will usually be superior to the concentrator network on both a cost and effectiveness basis, except when the line runs are extremely long. This result is due to fewer terminals and lines being required for the point-to-point network for a given level of effectiveness or cost. In the case of a concentrator network, the additional processing time introduced by the concentrator(s) requires the input traffic to be distributed over a larger number of terminals and lines in order to achieve a given system response time or thruput. This results in higher cost for given levels of effectiveness or, alternately, lower effectiveness for a given cost. The concentrator network is particularly at a disadvantage when low response time, high thruput or low mileage line runs characterize the network. These results do not hold as the length of the network becomes large, because line charges will eventually dominate cost considerations and the point-to-point network becomes excessively costly.

A different situation pertains when a fixed number of user terminals must be employed, due to a geographic or organizational requirement for terminals. In this case, the economies of less equipment cannot be achieved in the point-to-point network. In this case, the point-to-point network will always provide shorter response time and higher thruput; however, cost will be higher. The following are the characteristics of the fixed terminal case for a given input rate:

- network cost rises faster in point-to-point networks as the number of terminals required increases
- network cost is significantly increased as line runs increase in point-to-point networks
- network cost increases negligibly in concentrator networks as line mileage increases
- differences in response time between the two networks decrease with an increase in the required number of terminals
- differences in thruput between the two networks increase with an increase in the number of required terminals.

These characteristics signify that the concentrator network has an advantage when the number of required terminals is large, line runs are long and response time is more important than thruput. Conversely, point-to-point networks have an advantage when the number of required terminals is small and line runs are short. Selection of network type depends on the relative difference in cost between point-to-point and concentrator networks versus the relative difference in effectiveness, for a given number of terminals and line mileage.

In summary, there is an important difference in relative network performance and cost depending on whether the number of terminals is fixed or can be varied in the network design.

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DROPOUTS AND PHASE-HIT EFFECTS ON DATA CHANNELS

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Data communication channels extending over more than a very few miles are subject to "dropout" and "phase-hit" effects which introduce error bursts. The dropout phenomenon is the more serious of the two, and is responsible for the most severe error occurrences. All long-haul, and most short-haul, communications media exhibit these effects to some degree. Advanced systems now coming into prominence, for example all-digital networks, will relieve but not eliminate the problem.

Dropouts, or brief signal interruptions lasting perhaps one to 1000 ms, result from a variety of causes. Protection switching on microwave radio, either automatic or manual, causes momentary losses of signal. The efficient one-for-five protection systems used for long-haul service involve longer switching times than the simpler one-for-one arrangements used in short-haul applications. Troposcatter systems are subject to brief, deep fades which effectively block the data signal. The occurrence of fades on all radio systems, line-of-sight particularly, depends on seasonal and diurnal effects. Hence the dropout rate can be expected to change with time. The quality of radio maintenance, by affecting the tolerable fade depth, has its influence on the dropout rate. PCM carrier systems occasionally lose framing, resulting in brief signal losses. Protection switching on coaxial cables results in the same effect. Maintenance and patching activities on any system induce dropouts, as can equipment defects. The age of the equipment design naturally affects its tolerance to such effects as power transients.

Data will be presented on the rate of occurrence of dropouts on typical transmission facilities used for data transmission at all speeds, as taken from CCITT and Bell System sources and local studies. Because the same mechanisms affect them equally, dropout durations and rates of occurrence are expected to be similar on all data channels, teletype-speed through wideband.

The rates of occurrence for dropout effects are extremely variable from one facility to another, even on identical routes. The same holds true for different directions of the same data channel. The variability affects both the typical duration and the number of events per unit time.

Phase hits are an effect of secondary importance. These are sudden jumps in the phase of a received data signal. Principal causes are differences in length between protection-switched coaxial cables in the same sheath, and switching of carrier supplies in FDM multiplex. Radio systems are generally designed to minimize phase shifts during switching, but are naturally open to any phase change in the multiplex equipment. Phase changes up to 360° can occur and last any amount of time. Slower changes - "phase crawl" - also occur.

Phase-hit effects are a minor cause of trouble in comparison with dropouts. Unfortunately, most commercial phase-hit detectors respond also to dropouts, since phase becomes discontinuous when a signal loss occurs. Likewise, impulse noise can also result in erroneous phase-hit totals.

Phase changes of 30° or more on long-haul channels are usually much less frequent than 30 times per hour, as an upper bound. Short-haul facilities are essentially free from phase hits.

Both dropouts and phase hits result in bursts of errors. The seriousness of these impairments depends naturally on the speed of transmission, but also on the data organization (character-interleaved versus bit-interleaved multiplex, for example) and the block length. Forward-acting error correction is frequently effective against the shorter bursts; ARQ systems are favored in the face of long bursts. The interval between bursts is also important. Directly-multiplexed data systems with no protection means are extremely susceptible to these effects. Speed of sync recovery in data sets and multiplexers is of obvious importance, as is the length of the signal loss required to cause an automatically-equalized data set to retrain. Data multiplexers operating back-to-back between different transmission channels without trouble monitors or other means of sectionalizing error bursts are both extremely susceptible to sync loss and virtually impossible to troubleshoot. The makeup of the circuit has its own effect on the burst rate; most long circuits are composed of both short- and long-haul facilities in tandem, and a great many long-haul channels are comprised of both radio and cable sections. In addition, the relative amounts of coaxial cable and radio in a particular long-haul channel may change frequently as the communications carrier's growth program progresses.

Dropouts and phase hits are a routine occurrence on data communication channels. A successful system design must include safeguards against the error bursts that they cause.

THE RJE ENVIRONMENT:
HIGH-SPEED VOICE GRADE COMMUNICATIONS

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While a great deal of attention has been paid to the development of timesharing systems over the last several years, remote batch systems have developed as a practical method for using computers. Remote Job Entry (RJE) systems provide access to a batch oriented processing system such as the CDC 6600, the IBM 360/65, or the UNIVAC 1108 through a high throughput oriented terminal. The operating systems on these computers provide the remote user with all the capabilities available to the on site user; as a matter of fact, at ISD the service provided the terminal user is better than the service provided to the in-house user.

The typical remote batch terminal consists of a 300 card per minute reader and a 300 line per minute printer and costs about $1,000 per month. Terminals with both higher and lower speed peripherals are available. The throughput of these terminals are determined by line speed as much as peripheral speed. Peripherals such as tape drives and plotters are available but are seldom used.

Communications facilities range from dial-up to wide band systems. A dial up facility with 2000 bits per second (bps) data sets with their 150 millisecond turnaround time provides an average throughput that ranges from 80 to 150 lines per minute. Four wire leased lines provide from 200 lines per minute at 2400 bps to 700 lines per minute or more at 9600 bps. A four wire leased line to any two points in the Bay Area costs about $150 per month. Modems cost from $75 per month for 2400 bps modems to $380 per month for 9600 bps modems. A terminal with 300 lines or cards per minute capability, a 2400 bps modem, and a leased line would cost about $1,500 per month.

The communications schemes used in the RJE environment have two prime goals, one is error control, and the other is the maximization of effective throughput.

Synchronous transmission facilities are used with the RJE terminal. This means that a message of several hundred to a few thousand bits are transmitted in a block. The block is preceded by a sequence of a unique character called the SYNCH or synchronization character in order to differentiate between a true message and noise. If none of the SYNCH characters are recognized the entire message is treated as noise and dropped.

The nominal line error rate of one in 10^5 means that on the average every full page will contain one error. This error rate is far too great considering that a typical job produces 30 to 50 pages of output. Each block has check bits to determine whether bit errors have been made in the block. If the block has been transmitted correctly, an acknowledgement message (ACK) is sent back to the originator of the message to signify a correct transmission and that it is time to send the next message. If the block has not been correctly transmitted, a negative acknowledgement (NAK) is sent back to signify that the previous message should be retransmitted. Messages may also contain a sequence number so that a block that is dropped completely will be detected. Time-outs are also used to keep the terminal and the central computer coordinated.

Because of the 150 ms turnaround time on dial up, it is important to use large blocks. Throughput using 300 character blocks is twice that using 80 character blocks. However, the longer the block, the higher the probability of a transmission error occuring and the higher the cost of a retransmission. On a four wire full duplex line where there is no turnaround time, the effect of blocking is not large.

A second technique that is used is to increase the information content of each bit. This is done by the use of data compression techniques. The simplest of these is to truncate the record after the last nonblank character. Another is to use tab stops to truncate after the last nonblank character within a group of characters exactly like the way that the tab key on a typewriter works. A more sophisticated scheme is to replace multiple instances of a character with a count together with the character that is to be replicated.

The communications system is debugged primarily by using a test set which sends random bit patterns over a looped back line and checks them when they return. The test set has a bit error counter which can be used to check error frequency on the line. It can also be used to locate modem problems.

The main problem with maintaining the system is fault location. A problem may exist in terminal hardware, terminal software, modems, line, central site hardware, and last, but certainly not least, central site software. Reliable fault location is especially important since debugging individual components in the system can be quite difficult and time consuming.

The complexity of maintaining a high level of service in a synchronous communications network of more than a few lines requires a high level of technical capability today. It is necessary to control software, hardware, and communications facilities. However, major changes will come about in the last half of this decade with the advent of all digital networks from both Bell and independent suppliers. Modems will no longer be necessary. The reliability of data transmission will be much higher than it is today, and the people maintaining the communications facilities will be better equipped to debug the system. The cost of these services should go down and new services will be made available. The all digital network coupled with better control of the software will make RJE a commonly used method to distribute computing power.

"Communications in a Time-Sharing Network"
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The typical time-sharing service provides its customers access to a computer through a terminal located on the customers' premises. The terminal communicates with the computer through the appropriate modems and the DDD network. A customer time-shares the computer with other customers. This is accomplished, in the computer, by alternating the work from one task to another. Thus, the total operating time available is divided among several customers. Time-sharing systems are designed so that each customer seems to have the computer dedicated to his tasks.

The design of a time-sharing network must be consistent with the design of the time-sharing service(s) that will use it. The factors that must be considered are:

1) Response: The customers' most readily accessible measurement of a particular time-sharing system is the response time -- the response time being the time between the customer striking the carrier return and the terminal receiving the first character back from the system.

   Response delays introduced by the network add to the delays caused at the computer. The total of these delays must fall within the acceptable range for the action taken, i.e. response required on entering a line of data is faster than the response required for a command. The design and redesign of a time-sharing network must take into account the effects on response experienced by the customer.

2) Reliability: The hardware and software that make up the network must give the customer uninterrupted access to the time-shared computer. When failure occurs, backup procedures must quickly go into effect to minimize the impact on the customer.

   The network must provide error detection and/or correction capabilities consistent with the needs of the customers. The time-sharing network must, to some degree, compensate for errors encountered on the voice grade lines.

3) Function: The function provided by the time-sharing network produces revenue. The function provided by a typical network includes:

   a) Customer access at some number of cities (FOB points).
   b) Simultaneous access by n customers.
   c) Support of different terminal types.
   d) Support of different line types.

4) Cost: The cost of the network includes hardware and possibly software.

The Service Bureau Corporation's telecommunication network has evolved from several small networks, each servicing a small geographic area to one nationwide network. The evolution progressed from networks of FX lines to a network supported by programmable data concentrators. This evolution is examined with respect to response, reliability, function and cost.

"Simulation in Computer Communications"

by

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Since the upsurge of computers that began in the 1950's, there has been a rapid growth in data communications over the voice and wide band networks. The rapid growth of the computer field and its applications, the use of time-shared systems and the tremendous amount of data to be handled is putting an enormous pressure on the present communication networks.

Because of the huge amount of capital needed to provide the facilities required, and because of the change of the nature and the scope of the information processed and transmitted, deep concern has developed at high management levels on a number of issues related to the subject of computer communications. Some of the questions asked are: (1) Are we making use of the newly developed technology? (2) The computer and communications fields are changing fast.... is it proper to invest now or wait for some breakthroughs in technology....are they around the corner? (3) Could we provide the services needed now and the ones required in the next decade or so with the technology available at present....is expansion possible without degrading the system? (4) For good quality service....how much does it cost?....Could it be done at less cost by better utilization of machines, lines, manpower....etc.? (5) What are the trade-offs?

For an investment of a few billion dollars over the next few years, we are expected to answer these questions....in the best and most honest way we can.

For investment in that order, we the scientific community have to provide the management with means and tools to make the decisions.

Simulation, with all its varieties, is expected to emerge as the most important tool, but unfortunately it has been used in certain cases to push certain products on the unsuspecting customers by flooding them with all kinds of tables, charts, languages, etc.

It is our duty and we have the obligation of establishing an acceptable set of rules in order that simulation will be used to give the customer the best for his investment.

This paper covers the development of the simulation technique to its present state. Proposals are submitted on trends which should be adopted in simulating the computer communication system or any of its components.

INTERACTIVE MANAGEMENT OF MINERAL RESOURCES

Practical experience with the Alaska data-base

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This paper reports on a series of experiments done by the authors using an information-oriented language named DIRAC-2. The purpose of these experiments was to demonstrate how advanced computer storage and retrieval techniques could be applied in the Earth sciences to provide planners and researchers with a flexible information tool.

Information needs in the Earth Sciences

The information needs in the geosciences fall into three rough categories:

(1) Planners at the regional or federal level need accurate, high-level correlations of many combinations of parameters.[2]

(2) Mining companies and other private operations require large quantities of geological, historical and bibliographic data on the resources of a particular region, property or mining district. This often includes history of past production as well as map location, type of rock, nature of gangue material, and so on.

(3) Researchers in public and private institutions need the ability to store economically the data found in the literature and to retrieve it quickly in response to unpredictable interrogations that are often statistical in nature.

First experiments

Our first series of experiments, covering the last few months of 1970, centered on the use of a fully-generalized data-base system called DIRAC-1. This system was of interest in the present context because it allowed us to rapidly create and develop models for information structures applicable to mineral properties.[1]

In 1971 an advanced version of DIRAC was privately developed and gave us increased performance together with the ability to obtain graphs and correlations directly on a video display tube.[3]

The case of Alaska

The rapid development of the mineral resources of the state of Alaska has created a situation that is highly suited for analysis from the data structure point of view. Not only is information scattered among many specialized centers, publications, and public or private files, but it comes with a variety of formats and coding systems. We were fortunate in receiving the advice and help of the U.S. Geological Survey in defining a uniform record structure for the mining resources in Alaska and for the literature concerning them.

The Language

The system we are using to store and retrieve this information is a very high-speed, interactive language that has the following features:

1) It operates in time-sharing mode on a 360/67 computer. The file is stored on a random-access disk.
2) Search commands allow the step-by-step definition of subsets of the main file. Selected records can be displayed directly at the remote terminal.
3) The full range of logical operations (inclusion, exclusion, negation) is available.
4) Subfiles can be created and saved dynamically under user control.
5) Use of the system requires no previous knowledge of programming.
6) Correlation matrices can be computed and displayed on cathode ray tube equipment. For instance, the correlation between type of rock and elements produced can be generated with a single command for any given subset of the Alaska file.
7) Histograms can be created and displayed on the scope in the same manner.

The commands combine to provide a flexible decision-making tool that has not been available in this field before.

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ABSTRACT

Coding Requirements of Digital Remotely Controlled Systems

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This paper is an analysis of the state of the art of modern coding schemes and their physical realization. The introduction of digital process computers in the fields of supervisory control, digital communication and remotely controlled plants and objects introduced a complexity in data transmission in communication among these computers and the associated data links. Also, large industrial systems such as chemical processes and modern power systems involve several subsystems located in stations miles away from one another, and each subsystem is provided by a minicomputer for supervisory and control purposes. The major system has one large process computer located at a central station whose functions are mainly optimizing the total process performance through hierarchial control, and coordination of action among the stations mini-computers. Important data information is interchanged continuously over noisy channels in this hierarchy. Therefore, reliable means should be available to provide secure data interchange in order to exert correct and accurate control actions by the actuating devices in the remote stations and to avoid receiving erroneous information at the central station. The main objective in computer communication is high data transmission rate with small probability of error. Shannon's channel capacity theorem puts an upper bound on data transmission rate for optimal error minimization and shows the existence of coding schemes that minimize the probability of decoding error. This paper will review and analyze coding schemes that are capable of detecting and correcting burst errors of finite length and methods of physical realization of these codes. Special emphasis will be devoted to polynomial codes and Bose-Chaudhuri-Hocquenghem (BCH) Codes. Since these codes are defined over binary Galois field GF (2^m), a survey of the theory of Galois field will be given in the paper. Linear sequential circuitry methods will be utilized to implement these codes, and the problems associated with implementation of long code words will be treated.

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CHANGING COMMUNICATIONS TECHNOLOGY

AND THE TELE PROCESSING BOOM

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Abstract

The healthy data communications expansion in California is an outgrowth of the host of data processing vendors and users who serve this area. New markets and new services appear every day. Those who are not using remote data processing now may well be large users of data communications in the future.

This teleprocessing boom not only increases the number of data communications circuits, but it also results in increased transmission speeds. Both new and existing communications common carriers are looking for ways to satisfy the voracious hunger for information transmission that the teleprocessing market stimulates.

Concern for the ecology of computers and of communications is of primary importance. Three natural resources are basic to the communications ecology:

(1) space,
(2) bandwidth,
(3) time.

Space resources are consumed by cables in underground ducts. *Bandwidth* resources are consumed by microwave radio channels. *Time* resources are consumed by transmitting signals in a fixed length of time. Economic factors heavily influence which resource is used.

The communications carriers strive to use their resources effectively and efficiently. This means there is a continuing demand for devices that efficiently use a voice bandwidth channel for high quality, high speed data transmission. As technology progresses, the information transfer rate on voice bandwidth channels has increased from 1200 bits/second to 9600 bits/second and even higher on some circuits.

At the same time, second generation data services are becoming popular. They satisfy a need for fast transmission speeds to permit computer load sharing, magnetic tape transmission and high speed facsimile reproduction. In the past, such services generally used more spectrum.

About the same time that wider bandwidth services were growing, a time-division multiplex system was being introduced for voice bandwidth transmission in the Bell System.[1] This system, called T1 carrier, has had a profound influence on the communications industry. One might say that each voice bandwidth channel in a T system is trading *time* for its equivalent *bandwidth*. That is, each voice channel has end-to-end control during its particular sampling interval only.

Digital techniques are used to transmit the voice samples. Consequently, high speed digital data communications users now have the ability to get from one location to another without converting an on-off (digital) signal to a band-of-frequencies (analog) and back to digital again at the distant end.[2,3]

The digital network that the Bell System proposes for service in late 1973 or early 1974 can be used to interconnect these T carrier systems to provide highly reliable and accurate digital data channels.[4] An order of magnitude improvement in error performance over the present switched network can be expected. Figure 1 shows the interconnection hierarchy for digital systems.

Name	Equivalent Number of VB Channels	Bit Rate (Mb/s)	Type Line
Digroup	24	1.544	T1
Super digroup	96	6.312	T2
Master digroup	672	46.304	-
Jumbo digroup	8064	560.160	-

Figure 1 - Digital Hierarchy

Digital channels will be provided by other means in addition to T carrier. A new development will enable the Bell System to use its extensive microwave radio network to meet the rapidly rising demand for digital data service. In addition, a unit is under development to transmit 6.3 megabit/second bit streams on coaxial cable.[5]

A digital data transmission network has advantages and disadvantages to both common carriers and users. For the foreseeable future, data communications channels will undoubtedly be a mixture of both analog and digital. When the signals to be transmitted are already in digital format, digital channels and time-division multiplexing will be advantageous if their use can be shared over a variety of services.[2]

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THE BACKGROUND, ECONOMICS AND APPLICATION OF THE CASSETTE TERMINAL

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Viewed historically, the technological advances in developing complex computing devices has moved at a far greater pace than the techniques for getting data into them. The punched card, the prototype of which was first used in the 1890 census, remains anachronistically the principal communication medium between man and computer. Recent developments in source data automation, however, have provided an alternative to the punched card approach. This alternative, the cassette terminal, has significant technical, organization, and economic ramifications.

Technically, the cassette terminal is identifiable by an architecture usually consisting of a keyboard, video display screen, singular or multiple cassette recorders, and a central micro-processor. The micro-processor performs a variety of functions in linking together the various components. These functions include data editing and searching, arithmetic operations, matrix or "table look-ups", and data communication with a central computer or other terminals. Additionally, the cassette terminal can be equipped with peripheral devices including printers, card readers, and mass storage units. In that the micro-processor is directly programmable via either the keyboard or by stored cassette record, the cassette terminal becomes a powerful tool for not only the capture of data but also for its ultimate disposition within the framework of the modern organization.

Little has been said by social scientists as to the impact of computers on modern organization. Correlatively, nothing has been said with respect to cassette terminals. Yet, the cassette terminal can potentially alter the structure of every large centralized organization. Most notably the cassette terminal can serve as the arbiter between the forces of centralization and decentralization. That is to say, through its inherent flexibility, the cassette terminal can establish an equilibrium between the frequently competing forces of organizational unity and diversity. This equilibrium is most quickly identifiable at the middle management level of the organizational structure. It is here that the demands of centralized standardization conflict with the innovative and personal values of the unit manager and his staff. The cassette terminal provides an equilibrium between these forces by serving centralized information processing with standardized data inputs, and, concomitantly providing the unit manager with independent control of data aggregation, display, and formating. Furthermore, it does this at an economical level competitive with the traditional punched card approach to data entry.

To establish the economic impact of the cassette terminal, a cost study was undertaken by the Santa Cruz campus of the University of California in the Spring of 1971. This study was premised on three major hypotheses:

1. Hypothesis I. In an organizational environment in which computer data is first manually coded and then independently keypunched or keytaped, cost savings can be derived by automating the coding process such that that process directly produces the computer input medium.

2. Hypothesis II. If the validity of Hypothesis I holds, then it can be further demonstrated that the derived cost savings will vary proportionately with the magnitude of the data being coded.

3. Hypothesis III. Additional cost savings can be generated by automating office procedures not directly associated with the creation of computer-compatible data.

To test these hypotheses, an organizational environment was quantified using various workload measures. This test environment consisted of the campus Financial Aid Office and the integration of its operations cycle into a computerized, Universitywide information system. Findings of this study showed that with respect to Hypothesis I, only minimal savings of 3.6% would be derived over traditional data entry techniques if a cassette terminal were implemented at a low enrollment level of 4,100 students. However, in support of Hypothesis II, significant savings of 37.5% would occur as campus enrollment increased. In testing Hypothesis III no significant cost savings were found. It should be noted, however, that the organizational procedures in this last case were evaluated using a cassette terminal without full arithmetic support, high-speed data search, and "table look-up". It is expected that further studies involving these factors will demonstrate additional savings using the cassette terminal approach.

COMPUTATION AND COMMUNICATION TRADE-OFFS IN MILITARY COMMAND AND CONTROL SYSTEMS

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DoD is just now in the process of replacing a large number of obsolete small and medium scale first and second generation computers with modern, powerful, cost effective computers. Conceptually, these computers will form the hearts of interactive, remote job entry computer utilities that will place an unprecedented load upon existing digital data transmission facilities. In short, the tremendous technological explosion in digital data processing capabilities may be creating a mismatch between processing and transmission costs. The CACTOS Project was created, under the sponsorship of DoD's Advanced Research Projects Agency, to investigate the cost effectiveness of various trade-offs among computation and communication capabilities that might lead to the design of optimal teleprocessing system networks.

Potential sources of cost effectiveness in designing alternative digital data systems lie in the economies associated with advancing technology, increasing scale, improving quality, specializing and simplifying processes, integrating functions, and minimizing network topologies.

It would appear that taking advantage of the potential for technological development yields the most return for cost effectiveness comparisons. Costs per unit of operation for central processing units have been chopping by an order of magnitude about every six years. For transmission facilities, the decrease in costs have been obscured by the pricing policies of the public utilities and the FCC, but appear to approach an order of magnitude in about 20 years. The development of storage media and terminal devices have not progressed quite as rapidly, but rapid advance appears certain for the future.

The economies of scale are the second most promising source of cost effectivity, but tend to be correlated with technological advance. These two potential economies provide the impetus for many extensions and consolidations of digital data processing systems. The economies of scale seem to vary considerably with the task for central processing units, varying from economies greater than Grosch's law to approximately straight line relationships. Potential economies of scale for communication systems seem large, but again are somewhat obscured by public pricing policies.

The economies of quality lie in improved reliability and reductions in error rates. The advantages of quality are obvious and very high quality can be obtained through system redundancies and error detection and correction techniques, but these techniques tend to be expensive. As with scale, the cost effectivity of quality is correlated with technological advance. One of the most promising technological advances for quality of data transmission is pulse code modulation (PCM) and time division multiplexing. All digital systems based on LSI logic and PCM/TDM techniques promise large gains in quality at considerable reduction in costs.

The economies of specialization and integration lie largely in avoiding the overhead costs of initializing, terminating and bookkeeping for complex job mixes and in creating standardized processers and processes that are perform more efficiently than general purpose machines and procedures. In this, specialization trade-offs are in contention with the economies of scale. However, future systems may depend upon gaining efficiency through multiprocessors and distributed logic (i.e., intelligent terminals and computerized concentrators and switches).

The economies to be found in minimizing network costs present a complex problem to system designers. Optimum routing may involve least dollar costs, least links, most reliable or least distance as well as traffic load considerations. Optimum locations for nodes and optimum connections present other problems. There are so many factors to consider in evaluating alternative computation and communication network configurations that general trade-off functions are difficult to derive.

Assessing economies for military command and control systems is complicated by the multiplicity of the performance criteria to be satisfied. Throughput, response time, reliability, and vulnerability are only a few of these. The benefit to be assigned to a particular performance criteria varies from system to system, depending upon the system mission. Much further investigation will be required before great precision in evaluating computation and communication trade-offs is realized.

SYNERGETIC MEASUREMENT TECHNIQUES FOR DATA TRANSMISSION

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Abstract

The transmission of data from one location to another requires a transmission systen or circuit. These circuits are composed of one or more transmission links, each of which has electrical properties that will modify the signal to some extent. It therefore becomes necessary to have some way to measure the amount of these signal modifications. Industry standards have been established for the majority of the different modifying circuit properties. Some of the parameters require measurement techniques not possible to implement without special test equipment. A number of the misunderstandings encountered between the Data and Communication industries are directly traceable to both not completely understanding these specialized measuring instruments and the circuit parameters they are designed to measure.

One of the most common offenders is impedance. The effect of impedances other than that specified for the Telephone Company interface on circuit loss measurements and gain frequency response is a frequent problem. An interesting example of this occurred recently. There was a difference of 1.8 dB between the circuit loss measurements of the data user and the Telephone Company. One was using a meter with a high input impedance and measuring bridged across the line of the circuit (the modem impedance specification was 600 ohms at 1000 hertz). The other used a 600 ohm instrument to terminate the circuit in place of the modem and measured the circuit loss. The 1.8 dB discrepancy in measurements was resolved when the impedance of the modem was measured and found to be 460 ohms and highly reactive at 1000 hertz. A termination such as this would also cause severe errors in gain frequency response measurements.

The practice of using a data signal to measure circuit loss has caused serious misunderstandings. With many data line signals being nonsinusoidal, the meter will give different readings depending upon whether the detector is peak, peak-to-peak, average responding, root-mean-square or root-sum-square. While each of these detectors may be calibrated to read the same on sine waveform, there are considerable differences between them (on rectangular pulses for example).

Another common problem is the measurement of circuit noise using a wide bandwidth response meter. One customer measured circuit noise in dBm using a popular AC VTVM. With a response of greater than 1 MHz, the meter actually measured the RF field of a nearby radio station. Even without nearby RF fields, we have seen differences of greater than 30 dB between band-limited noise meters and wideband AC VTVMs. High frequency noise not only has a greater effective noise bandwidth than voice-frequency noise sets, but the cable crosstalk is much worse at higher frequencies due to the cable capacity showing less capacitive reactance at high frequencies. Switching noise, analog and digital carrier systems all have considerable high frequency components that do not affect voice-frequency systems. The communications industry noise test sets have filters arranged for different weightings. The most common of these have roughly 300 to 3000 Hz passband.

A more subtle measuring problem recently was discovered with phase jitter. Two phase jitter meters of the same make and model gave identical readings at one jitter rate and yet differed by 100% at another jitter rate. This was due to a difference in the low jitter rate response of the two instruments.

Each impairment such as envelope delay distortion, noise, phase jitter, phase hits, gain hits, drcpouts, harmonic distortion and frequency shift has its particular measurement pitfall(s). It is imperative that our industries make every effort to understand the peculiarities of the language and equipment of the other if we are each going to do an efficient and effective job.

HUMANITY IN MEGABITS AND MICROWAVES

(Introduction to a seminar session)

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ABSTRACT

The question has been asked: What is the computer/communications marriage's impact on society? Attempting to find answers, we must first seek some useful definitions. These concern society and values, in particular.

Society. What society are we talking about? Is it the conglomerate of millions whose single common denominator is nationality? Is it a more specific culture within the national society, such as the white upper middle-class in the midwestern United States?

Reaching beyond the arbitrary limits of the nation- is it the international society of futurists, for example? Appropriately, at this point, we may ask whether any of these societies is to be considered as it appears now, or as it may appear at some time in the future.

For each of the societies so defined, an impact would be discernibly different. Very likely, for each society we might find multiple impacts of particular computer/communications patterns. When we summarize, we would have a large matrix, relating societies to possible impact patterns. Until we have that matrix and tested methods to apply it, we should be wary of impact generalizations, as well as of exaggerated conclusions drawn from isolated, narrow-focus impact studies.

Values. The continuous development of computer/communications complexes postulates that megabits married to microwaves represent values in their own rights. The opposition to this view frequently emphasizes dehumanization, meaning a loss of human values. Perhaps both views are too one-sided. We might learn from our experience with ecology and formulate our lesson as follows:

Any definition of optimizing the human life experience- and it is clear that there are many such definitions- centers on the concept of balance. When any contributing element is allowed to grow beyond a certain critical relationship to other elements, the conditions for balance are seriously disturbed. The same seems true when the opposite happens- that is, a reduction of a contributing element below a certain critical value.

Disturbance of the balance does not necessarily mean degradation in a human value system- but it does mean that a new balance needs to be found. In an increasingly man-made environment, that balance may not come naturally. Mankind will have to work on it consciously.

Applying this concept to the computer/communications syndrome, it seems to point the way to a most urgent task at hand. That task is the study of a required balance of the rational and irrational human dimensions. Technology provides us with the fruits of our rationality; the taste and the quantities of these fruits are rapidly changing. What can be done to the fruits of our irrationality, to restore and maintain for us a balanced diet? This question needs to be explored, no matter how elusive the answer may be. Possibly we may find the outlines of an answer, in the very act of the exploration. A first, useful step in that direction might be an exploration of their own irrationality on the part of those who practice the rational technology. We may discover a significant relationship here. If nothing else, we might experience more recognition for the irrational human side- a prerequisite of the search for balance.

Conclusion. To evaluate impacts on societies, definitions and exploration of human society and value systems are needed. This is a continuous task since impacts are continuously changing. At given points in time, a specific impact may be predicted or statistically evaluated. While some of this narrow-focus can be very useful, much of it may be comparable to evaluating the impact of colliding cars on a crowded highway. The statistics are reliable and the predictions reasonably accurate- but they contribute little to a better balance of traffic needs and facilities.

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SOCIETY: KEY ELEMENTS FOR THE FUTURE

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One of many ways of studying society involves a "values approach." This approach takes the view that the principal moving forces in contemporary American society are the changing needs, values, and beliefs of key segments of the population; that this nation is in the midst of a truly major phase-change into a "higher" set of values; that the emerging post-industrial future will be based upon these new patterns of needs, values, and beliefs; and that current trends can lead to the kind of pluralistic and prosperous future most of us say we want.

Society can be richly--even elegantly--described in terms of some number of groups of people sharing certain patterns of needs, values, and beliefs (NVBs). These NVB patterns can be arrayed hierarchically in terms of levels of development as described in the schemata of human growth proposed by modern personality theorists.

Each of these NVB groups pursues different aims in different styles. Core needs evoke supporting values and beliefs and vice versa. And so a person (or a nation or an institution) in evolving through the stages of growth takes on profoundly different interests and life patterns as he grows. A poverty-stricken man, for instance, may devote almost all his time to surviving physically. Dog-eat-dog morality animates him. However, as his food and shelter needs are satisfied he turns his attention to protecting what he has. Suddenly respect for law and order replaces the earlier dog-eat-dog style. As he progresses, his central interests may eventually turn to accumulating material things as symbols of achievement. At first, his wordly goods are evidence that he has risen above the poverty level. Later, they become symbols of high status in a society which evaluates men by their wealth. The man's style becomes acquisitive, driven, and competitive.

There are influential groups now in the American society which have passed beyond these stages. They pursue goals which are beyond the imperatives of economic prestige. Although their numbers are still small, they tend to hold positions of disproportionate importance. When young, they tend to be among the student leaders; when older, they often appear in upper professional and management posts. This group--which we call the unfolders--seems to be the cutting edge of the future.

This way of looking at society suggests that the seeming chaos of societal trends, the about-faces, the unheralded events, the surprises unforseen by even the most acute observers stem from the emergence of a critical mass of unfolders within a society dominated throughout its history by materialistic, scientistic, deficiency-driven concerns.

If this interpretation is anywhere near the mark, there are at least three types of futures that could result.

First, it is certainly possible that the forces of inertia, status quo, and tradition could become so alarmed--even shocked--that they would impose iron suppression on society, resulting in some variant of the authoritarian state. A second reaction could be that of tokenism in accepting the values of unfolders. This seems reasonable to many on the grounds that this nation would be foolish indeed to discard wholesale the NVB system that has served so well for so long.

But need the baby be thrown out with the bath water? A third kind of future might be built by selecting what is healthiest from the old and the new. So, as a nation, we would ask what human needs, values, and beliefs we wish to foster <u>in addition</u> to those provided for within the more limited framework of achievement values. The question is what we wish to add, not what we must lose; it is a question of where we want to go, as well as what we choose to flee from.

What, it seems to me, we should be aiming for is a "synergy society," to use Ruth Benedict's phrase. The synergy society is one in which the act of each individual serves not only his own good but that of the society. As a profound wit said, it is a society in which virtue pays. The synergy principle should do for the post-industrial society what the marketplace principle did for the industrial world: it should provide a mechanism by which the myriad, short-term, daily decisions taken in isolation by people in their personal and work lives add to a healthy and workable long-term development of society as a whole.

But how might the "values approach" to social analysis be implemented?

One would first wish to identify some manageable number of NVB sets that would adequately describe the American people. These clusters of NVBs--perhaps ten to twenty of them--can be visualized as layered strata arranged hierarchically within the society. One would then seek to correlate with these NVB groups more usual characteristics such as SES, demographic attributes, economic and political characteristics and so forth. Such information would provide one approach to the crucial task of forecasting NVB distributions in the future. In addition, depth interviews with members of each significant NVB group would ferret out their emerging and receding values, social concerns, hopes, fears, dreams, plans, life styles, and so on. These data would be analyzed for qualitative shifts within NVB patterns, changing numbers in each cluster, trends in discrepancies between expectation and reality, alterations of power distributions, etc. The influence of environmental factors would have to be systematically considered. From these studies should come better intimations than we now have of nascent social trends, their points of origin, their proponents and opponents within and across NVB groups, their timing, force, style of expression, direction of development, and so forth.

Studies of this sort should have great utility in a variety of research areas. For example, each NVB group could be studied for its sense of what constitutes the good life. Some sort of national quality of life index might ultimately be built up out of these data. If the approach could provide a "social radar," it should be helpful to organizations concerned with anticipating and responding to social pressures. Application of the approach within institutions should facilitate effective management and improved organizational development. Finally, on a national level, the kinds of insight provided by NVB studies should be useful in analyzing overall and subcultural goals, in identifying social hot-spots and hence in setting program priorities, and--of course--in setting national policies aimed at "inventing" the futures we select.

And so--to revert to the title of this talk--it could well be that the key element for the future of this society is the kind of people we are and have the wisdom to become.

THE SOCIETAL SIDE OF THE WIRED CITY

With the existing levels of communication awareness today, there is considerable effort being devoted to the perusal and conjecture of the role communication plays in creating social change. While some lay all of the ills of today at the footstep of telecommunications technology (TV particularly), others look to the emergence of the "Wired City" for the salvation of mankind.

In spite of its accepted mystique, there seems to be no explicit definition of a "Wired City". The words appear to be only a term used by a community of "experts" for their own purposes.

In reality cities have been wired for both power and communications for almost a century.

From the context of use the implicit meaning suggests Wired City is a broadband system likened to that used for CATV distribution. It is contended that the cliche really constitutes a security blanket under which the lack of comprehension and knowledge needed to design an adequate telecommunication systems for the future is hidden.

This paper is intended to provide a broad-brush look at many of the social factors which are felt to be relevant to communications/telecommunications understanding. The controlling elements for any "Wired City" are social and not technological in nature. Therefore pre-occupation with technology in advance of behavioural understanding is bad.

In spite of what the protagonists of "Wired City" might infer by the offered technological solutions, relatively little exploratory work in telecommunications has been done in an effort to understand more of the communications process.

The societal impact of the various/communications media can be judged by the proliferation and utility as perceived by the users.

What is the relative prominence you personally would give in your own home to the following communication media.

Television
Radio
Telephone
Film Projector
Phonograph
Newspaper
Magazines
Books

The order may vary a bit, but television and telephone probably consistently head the list of householder preferences.

In the future, additions to this list will appear and satisfy further needs. The prediction of these additions requires more understanding of future social behaviour. Appropriate technology will then be applied. If it is non existent at the moment it will be invented for the requisite need.

In other words technology will not determine how cities f the future will be wired. To plan for this w must understand impending changes in those areas considered to be cultural and social. These areas constitute that part of behaviour which is influenced by custom and learned. Thus it can be changed to permit need satisfaction.

For example when automobile transportation technology was introduced new codes of behaviour evolved. The early automobile drivers soon developed rules of the road by concensus these became distilled as custom and up with both social stigmas and taboos. Highway construction and design now reflects this.

In this context - wired cities will end up configured to match the behaviour patterns of the people - which is self evident.

Further proof of the societal nature of communication systems has been identified by Gordon Thompson, a scientist, philosopher at Bell-Northern Research in Ottawa. He has analysed the evolution of telecommunication innovation, and these common patterns related to displacement of one technique by another emerged.

Each succeeding invention increased.

1. The size of the shared common communication space
2. The ability to access stored information
3. The ease with which concensus could be established.

Recently it is becoming evident that there are two others. A fourth - the number of wealth-creating opportunities is increased, eg. the range of available options for commercial action is increased through the ability to communicate. A fifth - relates to an increase in the sensitivity of a culture to the consequences of remote activity.

All aspects of these measures involve information transfer between originators and consumers of information. It is evident that the distribution systems must recognize that Communications has these dimensions - it can function in real or delayed time. A real time system can provide for interaction or not depending on usage needs.

The storage of large quantities of information is a major physical problem whether in homes, libraries, or businesses. Computers now provide new capabilities for information storage which is beginning to be used extensively throughout the business community. This capability will eventually be extended to the community at large.

The person accessing the stored information has a usage related set of problems.

1. The information must be stored in a way in which it can be retrieved easily.
2. The stored information must be efficient in terms of the users behaviour.
3. The form in which it is to be used when it is retrieved requires consideration of the user and his preferences in terms of his utilization function.
4. The relevance of the offered information to the needs of the user.

Considerable time is being spent today talking about computer systems and information banks without specific reference to the social processes which would govern the use of the banks. There can be no effective design and development of these systems until this takes place.

It must also be recognized that all existing communication systems which have had a major societal penetration and impact have also generated a significant amount of standardization in the technology. Standardization is the result of an implicit concensus between the manufacturers and users after a certain amount of experience with operating systems. This experience leads to modification. The process proceeds with diminishing utility until evolution ceases and standardization occurs. Language is the most evident of the standardization events. Even so, there is room for major variance between large population/ ethnic entities, and within that, further room for individual variation.

This all relates to the process of concensus forming which we have noted earlier as one of the four factors in the determination of the communication media itself.

Within the context of discussion on "Wired City" it must be remembered that one of the features of society today is the mobility of people. One might argue that this reached is zenith with the automobile but modern aircraft have done nothing but expand the horizons. This mobility is changing the community of interest of peoples and with this change goes some of the foundations of the social environment under which many of us have lived. We find ourselves in the position of knowing that our "community of interest has changed". The early reality in telecommunications was a community closed environment. Within its physical boundaries an individual had his total set of relationships.

This has changed significantly in any community of moderate to large size. Failing this a larger segment of the population has been mobile and extended itself beyond the boundaries of the physical community which have been reflections of physical or political limits. In most cases it has been the political limit which has defined the community.

Within that community in terms of the interpersonal relationships individuals with mobility have established a pattern of relationships significantly different from the definitions of political communities within which the physical aspects of life are limited. (houses, voting rights etc).

In conclusion - there can be little doubt that technology and behaviour are related. However, in terms of future systems the controlling variable is the programming content itself. Beyond this, the technology used is influential only in terms of its efficiency. There is a degree of comprehension related to the technique used to disseminate it.

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American business is largely conducted by stockholder-owned corporations which operate for a profit. These business corporations may be divided into three major categories:

(1) Private corporations which engage in manufacturing, servicing, and mercantile activities that are motivated by competition. It is this "private" that appears in the title. The thought I will try to convey is how the Bell System will look in its new role as competitor.

(2) Financial corporations such as banks and insurance companies.

(3) Public utilities which provide indespensible services under monopoly conditions with government regulation of price, profits and service quality.

A T & T is the head of a family of regional operating telephone companies, each with its own president and board of directors. While A T & T owns the stock in most of them, the companies themselves are responsible for many critical, autonomous decisions, particularly regarding problems associated directly with their local operations.

A T & T also owns the Western Electric Company which manufactures or purchases most of the supplies and equipment used by the operating units, and jointly with Western Electric, it owns Bell Telephone Laboratories.

This basic structure has existed unchanged for the better part of a century. The basic structure and policy foundations of the Bell System were the brain children of one man - Theodore N. Vail. Vail was the first general manager of the original Bell Telephone Company organized in Boston in 1878 and the first resident of A T & T which was incorporated in 1885.

Vail patterned his structure of the telephone system after that of an existing institution that had more than proven its social and survival values - our own federal government. To Vail's mind, the "Federal" structure was that it provided for an effective division of responsibilities, and thereby an efficient means of managing very large resources. It was the goal of the fledgling telephone industry to eventually provide voice communication to points throughout the United States and as Vail put it, "by cable and other appropriate means to the rest of the known world."

Before his dream could be realized, however, something had to be done about the needless costly and wasteful duplication of facilities that existed then as a result of competition between telephone companies operating in the same geographic areas. Vail's solution was, "One System, One Policy, Universal Service". He campaigned vigorously for - and eventually won - government acceptance of what came to be known as the "common carrier concept." This concept which eliminates unneeded and uneconomical duplication of facilities has three virtues: Responsibility, Compatibility and Coordination.

First it pinpoints the responsibility for service so that regulatory bodies can more effectively represent the telephone-using public.

A second virtue of the common carrier concept is that it helps insure a close compatibility among the billions of intricate, interdependent parts that comprise the communications network.

The third virtue of the common carrier principle is that it permits a coordinated response to the communications needs and desires of telephone users, through application of what has come to be known as the systems concept.

The outstanding economic characteristic of public utilities is that they can operate at greater efficiency as monopolies. Public utilities operate at lower unit costs under monopoly that under competition by eliminating costly duplications of facilities and by achieving decreasing average unit costs as utilization increases.

Two examples of questions confronting the communications industry management right now are:

(1) What should the Bell System do to respond to the challenge of a competitor who has won FCC approval to provide specialized common carrier services between two of our large cities? Our rates are based on nation-wide average costs. The charge is the same for equivalent distances regardless of whether the route carries heavy traffic and is therefore a low-cost route or a light traffic high-cost route.

You can see that nation-wide average pricing has been a major factor in extending communications to the remotest parts of our great country. Should we abandon nation-wide pricing and price instead to meet or beat our competitor's prices, as we very well can on the basis of the costs we experience between these two cities alone? If we meet the competition and cut our rates on that route alone, won't that burden the remainder of our customers with higher costs? On the other hand, if we don't meet the competition, isn't it inevitable that we would lose business and therefore some of the economies of scale that permit us to keep our charges low to all our customers?

(2) Should the Bell System charge the customer what it costs to install his telephone? Mr. Vail's answer to that question was no. In his drive toward universal service, he believed that initial charges should be

kept low and that the costs of installation should be recovered from our monthly charges.

In summary, what effect will competition have on the communications industry? Long Range Incremental Costs and Usage Sensitive Pricing will become new phrases in our vocabulary. Prices will become more closely related to costs, but the greatest change will be in the general attitude. It will become more "marketing-oriented" by undertaking more market research programs, experimenting with new innovative services and generally being more responsive to special customer requirements.

ABSTRACT

THE IMPACT OF CYBERNETIC AND COMMUNICATION TECHNOLOGIES ON EDUCATION

A panel presentation by
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Educators, education institutions and students are facing increasing problems of cost and effectiveness. The explosion of information, the proliferation of careers and vocations and the requirements of our culture for more highly trained and educated professional and non-professional workers have placed demands on our educational institutions which cannot be met by the mere extension of our conventional teacher-classroom education system. With proper engineering, the technologies of communication and computers can be shaped into tools that will greatly improve the teacher's effectiveness and at the same time meet the diversity of learning needs of students. Far from dehumanizing the learning environment, the proper exploitation of technology can restore human interaction and learning in the affective domain to our schools.

This paper will discuss cybernetic and communication technologies and the utilization of these technologies to improve the quality of life in the learning environment.

Abstract

MACHINES AND TEACHERS

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Everyone is an expert on education. Each of us feels he knows what there is to applaud or to reject in the school systems through which he has passed. A concern about freedom vs. authority is one of the issues most often addressed in dialogues about public education; and many of the discussions revolve about the potential of modern technological devices and methods to free the student from the lock-step "tyranny" of mass instruction, so that he can proceed in the direction and at the pace most congenial to his abilities or interests. It is also ordinarily assumed that the teacher, too, will benefit from the employment of these technologies by being freed to pass on to the machine many of the onerous chores of record keeping and drill or practice type of instruction at the very least; thus permitting time for concentrating on the more creative aspects of the instructional process.

The simpler forms of technology, as teaching aids, have long been a part of the educational picture, but there is now the often expressed hope that the computer will soon be capable of offering a novel dimension to education, bringing the concept of individualized instruction much nearer to reality. Computer systems, as adaptive devices with the capability for operating in a logical mode, have indeed shown some promise of reacting effectively to differences in response among individual learners. However, most of the successful experiments reported in the literature have involved small groups of researchers working under more or less controlled conditions with a relatively few students out of the total school population. Extending the limited experimental findings, contradictory as they sometimes are, to large public school systems involves problems of such magnitude and complexity that no one can yet say with certainty what effect the new educational technologies will have when considering the overall objectives for a public school system.

This paper will consider some of the practical and philosophical problems related to applying technologies to the educational process.